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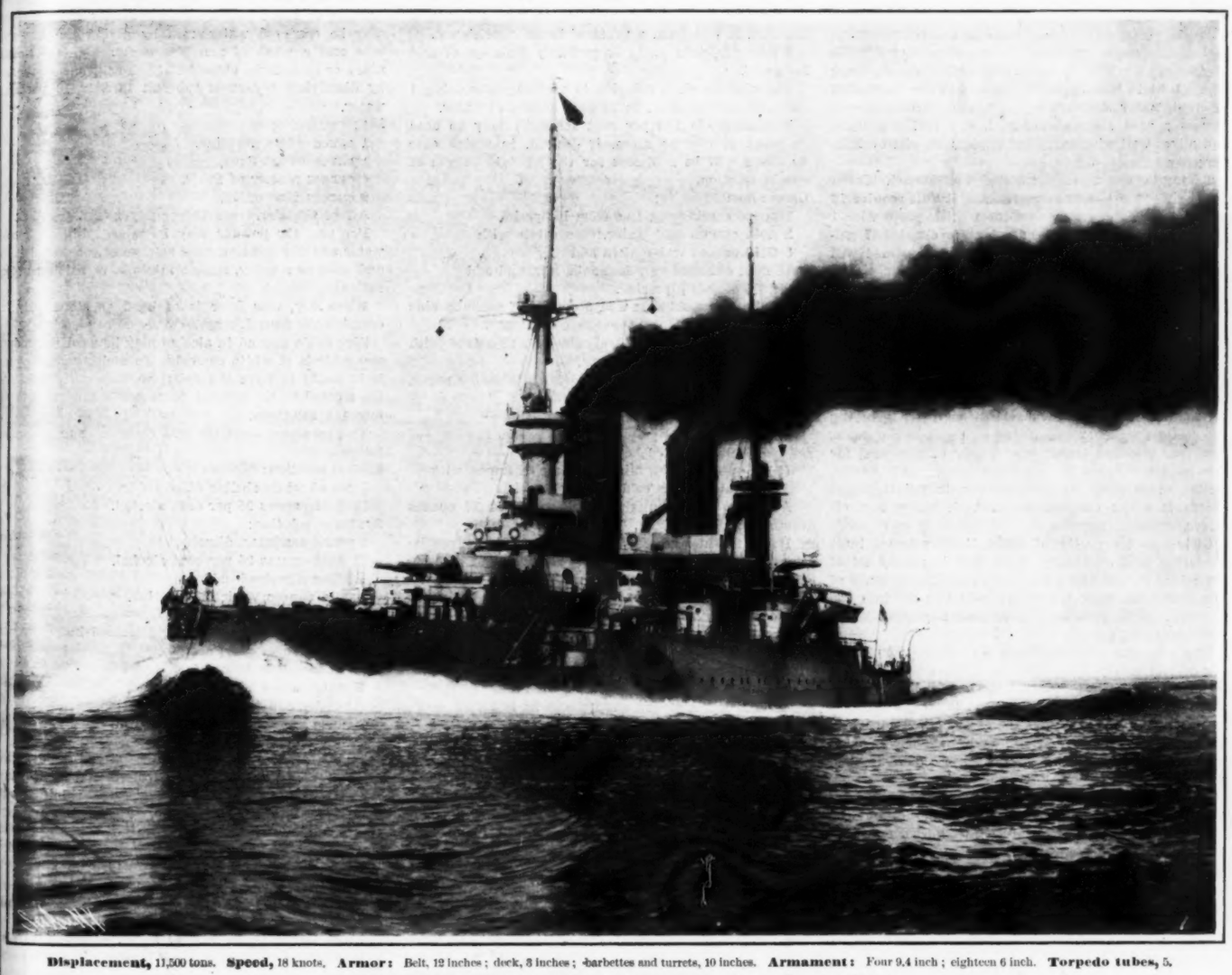
THE GERMAN BATTLESHIP "KAISER BARBAROSSA."

THE accompanying very spirited illustration of a German warship gives an excellent idea of the wave formation when one of these very beamy craft is being driven at full speed. The picture also gives an excellent idea of the military features of this vessel, which is one of a class of five ships of identical construction and value. Her principal dimensions are as follows: Length, 384 feet; beam, 65½ feet; maximum draft, 27½ feet, on which draft she has a displacement of 11,500 tons. Her complement is 660 officers and men. The ship is protected at the waterline by a belt extending from the bow to the wake of the after 12-inch turrets, its thickness varying from 4 inches at the bow to 12 inches amidships. The belt is 6½ feet in width. Above the belt there is practically no side armor, no attempt being made to protect anything but the turrets and their respective ammunition hoists. The main barbettes and turrets containing the four 9.4-inch guns are protected by 10 inches of Krupp armor, and the smaller, single-gun turrets and casemates, in which are mounted the eighteen 6-inch guns, have 6 inches of protection. The ship carries five submerged torpedo tubes for the 17.7-inch torpedo; one in the bow, where it is mounted in the characteristic German fashion immediately below the ram, and four others mounted in broadside. With the armor belt is associated a 3-inch flat deck, and this deck is continued to the stern, where it serves to protect the steering gear.

The vessel is propelled by three sets of vertical three-cylinder, triple-expansion engines, designed to give the vessel 18 knots with 14,000 horse-power. She can stow a maximum amount of 1,050 tons of coal in her bunkers, and she also carries 100 tons of liquid fuel in her double bottom.

The principal defect of these ships, judged by the latest naval practice in design and construction, is the small power of the main armament of 9.4-inch guns. These ships would have been far more valuable had they mounted the 11-inch piece with which the later German ships are armed. The lack of side armor above the belt, moreover, will expose the ships to severe damage from the high-explosive shells of rapid-fire guns. These defects, however, are being remedied in the later German ships, of which the last two or three classes to be built mount a powerful 11-inch piece in the main battery, and have good casemate and battery protection. The designs which are now being gotten out will carry a numerous battery, composed exclusively of an improved 11-inch long-caliber rifle.



Displacement, 11,500 tons. **Speed,** 18 knots. **Armor:** Belt, 12 inches; deck, 3 inches; barbettes and turrets, 10 inches. **Armament:** Four 9.4 inch; eighteen 6 inch. **Torpedo tubes,** 5.

GERMAN BATTLESHIP "KAISER BARBAROSSA" AT FULL SPEED.

HIGH BUILDINGS AND WIRELESS TELEGRAPHY.

A SEMI-PERMANENT wireless telegraph station has been maintained for more than a year by the French government at the Eiffel Tower in Paris, and it is stated that spark-messages sent with a 10-kilowatt installation have been read at Morocco in the south, and Nova Scotia in the west. Although advantageous for wireless telegraphy by reason of its height, the Eiffel Tower is not ideally situated in this respect. The ideal requirement is a tall structure of non-conducting or electrically disintegrated conducting material, supporting an aerial framework of considerable effective area, rising from a good electrically conducting sheet, for wave reflecting purposes, connected to good ocean ground to ship off the waves in all directions without loss after they have been generated. Mere height above sea level, such as is provided on a high mountain summit, appears to be of no benefit; since it is the height above the conducting ground base, or electric mirror, that counts.

It is announced that according to the plans for the reconstruction of the Mills Building on Broad Street, New York city, that structure is to be carried to a height of 1,000 feet, or 305 meters, above the base, so as to be by some 5 meters the highest structure in the

world. A wireless station at the base of this building, using the summit for the support of its aerial, should therefore be situated more favorably than the Eiffel Tower station in regard to proximity to the ocean, although less favorably than the Eiffel Tower in regard to the presence of surrounding tall conductors, such as the Singer and Metropolitan Life towers, or the Brooklyn bridge. It seems to have become necessary to bury the wireless plant at the foot of the Eiffel Tower in an underground vault, in order to preserve æsthetic appearances and to keep down the noise of the sparks in sending. The time will probably come when transmission by sparks from a large land station will be looked upon as clumsy and ineffective, by comparison with the more modern sparkless method of sustained oscillations, which have not yet had time to come into extensive use; but almost any station, even if noiseless in operation, would be likely to mar the graceful symmetry of the Eiffel Tower, and there would doubtless be justification for going underground on the score of appearances alone.—Electrical World.

ZINC OXIDE.*

PRACTICAL FORMULAS FOR ITS USE IN THE ARTS.

Zinc oxide is the white powder obtained by combustion, either from the metallic zinc or from the ore; it may also be produced by calcining the zinc carbonate salt.

Zinc oxide should be completely soluble in dilute sulphuric acid without effervescence, a property possessed by no other white paint pigment.

Oxide of zinc, unlike lead, is not affected by sulphur fumes or sulphurous gas, for the reason that the sulphide is white, or the same color as the oxide, and as both the sulphide and oxide are excellent and durable pigments, they may be used with safety and in cases where lead is inappropriate. Zinc white is unaffected by light, water, deleterious gases, etc., furthermore it possesses good frictional body, i. e., wearing surface, and mixes well with any kind of pigment, oils or thinners.

Taking the average volume (bulk) of French "Green Seal" zinc at 3½ pounds per gallon, it will require 16 pounds of the dry oxide to form a thick paste with 1 gallon of water; this is equivalent to about 4.57 gallons of dry oxide, and the paste color so formed will weigh about 16.83 pounds per gallon.

The "standard mixes" made use of by color grinders are about as follows:

Water color, 100 pounds dry oxide with 4 to 6 gallons of water.

Oil color, 100 pounds oxide with 2 to 5 gallons of oil.

Varnish color, 100 pounds dry oxide with 6 to 10 gallons of varnish.

Common raw linseed is seldom used for grinding the costly French zinc oxide, as it discolors the paste, therefore bleached linseed and poppy oil are used for this purpose.

Zinc oxide finds its greatest use in painting and enters into the composition of both water and oil colors.

Owing to its purity of color, light volume, inert character, and durability, it is used in nearly all of the mixed paints now on the market. The number of formulas containing zinc oxide will run up into the thousands, therefore only a limited number will be given in this paper.

The formulas presented may be relied upon as being correct, as the author has tried them all. Many of these recipes were originated by him and now make their first appearance in print.

In the following formulas the term "pure" will refer to Green Seal, Red Seal or similar brands of zinc oxide which do not contain more than 5 per cent of impurities.

The word "common" will apply to oxides containing not more than 12 per cent of lead sulphate, and the term "leaded-zinc" will be given to oxides containing from 12 to 30 per cent of lead sulphate. Where the term "zinc-lead" is used, it refers to the product in which the lead may vary from 45 to 55 per cent.

FORMULAS FOR DISTEMPER OR WATER COLORS.

Artists' Chinese White:

(a) ¼ ounce pulverized gum tragacanth.
2 fluid ounces distilled water.
(b) 4 ounces pulverized gum arabic.
16 fluid ounces distilled water.
(c) 4 fluid ounces glycerine.

Dissolve the above gums in the water without heat, stirring occasionally. The tragacanth does not dissolve, but swells up and makes a sort of paste. In about 4 hours' time both gums will be nicely in solution.

Mix (a), (b) and (c), then stir in 6 pounds (96 ounces) pure zinc oxide.

It will be found a rather difficult matter to get this much dry pigment into 24 fluid ounces of the solution, as the resultant mass is a solid cake of water color. Such mixtures are usually made in a chaser or in a roll-mill.

The above solution will answer for any of the moist water colors, using different colored pigments. Two grains of salicylic acid or 10 drops of oil of cloves will preserve the solution indefinitely, although it keeps well for several months without such addition.

Casein water-proof white:

1 ounce casein, stir until free from lumps in
2 fluid ounces cold water, then dilute with
4 fluid ounces water, then add
½ fluid ounce strong ammonia, when well mixed add
⅔ fluid ounce chrome solution (1 to 10), finally add
4 fluid ounces wood alcohol.

The above mixture makes 2 fluid ounces of liquid and if 6 ounces of pure zinc oxide, or an equivalent weight of the heavier zinc oxides, be mixed with this solution, it will form a paint of brush consistency.

When dry, this paint is perfectly water-proof and fire-proof.

The chrome alum solution is made by dissolving 1 ounce of chrome alum in 10 fluid ounces of water.

Formaldehyde (40 per cent solution) may be used in place of chrome alum, if desired, in which case 60 drops will be sufficient for the 12 fluid ounces of casein solution.

Casein flexible white:

1 ounce casein, mix free from lumps in
2 fluid ounces cold water, then dilute with
8 fluid ounces water, then add
¼ fluid ounce strong ammonia, stir, and add
2 fluid ounces glycerine.

To the above solution add 8 ounces of common zinc oxide to get a paint of brush consistency.

The pigment and liquid should be well mixed with the brush to get rid of lumps.

This paint is very pliable and is suitable for paper, leather and other flexible substances.

Common casein white:

(a) ¼ ounce pulverized borax, dissolve in
14 fluid ounces hot water.
(b) 1 ounce casein, mix until free of lumps with
2 fluid ounces cold water.

Add (b) to (a), mix well, then stir in 16 ounces common zinc oxide.

If the mixture be whipped with an ordinary revolving egg-beater the lumps will be removed and the consistency improved.

More or less dry oxide may be added according to the consistency desired.

Oleo-casein white:

1 ounce casein, mix with
2 fluid ounces cold water, then dilute with
12 fluid ounces water, stir well, then add
¼ fluid ounce strong ammonia, next add
1 fluid ounce glycerine, finally add
6 fluid ounces raw linseed oil, mix thoroughly, then stir in
8 ounces common zinc oxide.

This paint may be used as a primer on wood, paper, etc. It is water-proof and very elastic. More pigment may be added if desired, and it can be thinned with water, alcohol, oil, turpentine or benzine.

All of the casein paints containing ammonia lose the greater part of the alkali on standing, but this does not affect the quality.

Satin finish white:

2 ounces sal soda, dissolve in
32 fluid ounces, boiling water, then add
4 ounces granulated white shellac.

Stir constantly and let simmer until the shellac goes into the solution. Strain through cheese cloth, and when cold add
4 fluid ounces wood alcohol.

For use, add 2 pounds of common zinc oxide, or about 1 ounce of oxide to 1 fluid ounce of liquid.

If the solution is too thick, thin with water; if too transparent, add more zinc.

Sanitary zinc white:

(a) 1 ounce French or German gelatine,
16 fluid ounces cold water.
Soak 1 hour, then dissolve on water bath.
(b) ¼ ounce zinc chloride,
⅛ ounce chrome alum, dissolve in
8 fluid ounces hot water.
Mix (b) with (a), then stir in
12 to 16 ounces common zinc oxide.

The above is designed for a wall finish and resembles celluloid in appearance.

Silicate white (fire and water-proof):

⅛ ounce pulverized borax, dissolved in
1 fluid ounce hot water, then mix with
4 fluid ounces silicate of soda, about 36 deg. B.

When well mixed, add
½ fluid ounce light colored syrup.
Finally stir in
4 ounces common zinc oxide.

Silicate paints are used for fire-proofing wood, paper and canvas. They are very adhesive and set quite rapidly. Owing to their alkaline character they cannot be used with colors or fabrics affected by alkalies.

Stone or brick painted with ordinary silicate paint may be rendered water-proof by giving the dry silicate coat a wash of ammonium chloride (sal ammoniac) or of calcium chloride. Such solutions are made by dissolving 1 part of the salt in 8 to 10 parts of water.

Zinc cementite:

1 ounce white dextrine,
1 ounce wheat flour,
4 ounces plaster of Paris.
2 ounces zinc oxide.

All of the above are thoroughly mixed together.

For use, the powder may be mixed thin with cold water and the solution used as a paint, or mixed thick and used as a putty, stipple mixture, or raising preparation.

When dry, this filler is as hard as stone. By increasing the flour it may be made more elastic.

Zinc oxide ground in alcohol may be used to produce many kinds of white enamels. In making such paints it is better to have the spirit varnish quite thick, as the alcohol in the ground paste has a tendency to dilute the solutions.

The varnishes used for this class of enamels are as follows:

Shellac solution:

1 pound white shellac dissolved in
32 fluid ounces 95 per cent alcohol.

Sandarac solution:

1 pound sandarac, dissolved in
32 fluid ounces 95 per cent alcohol.
When dissolved, add
2 fluid ounces Venice turpentine.

Celluloid solution:

4 ounces soluble gun cotton, dissolved in
32 fluid ounces amyl acetate.
Let stand 10 hours, then add
32 fluid ounces amyl acetate.
Finally add the following solution,
1 ounce camphor gum, dissolved in
8 fluid ounces acetone.

All of the above varnishes are thick and are designed for white enamels. The two former may be thinned with alcohol, but the latter must be thinned with amyl acetate, ether, or acetone. Turpentine and benzine precipitate the cotton.

Camphor gum has the peculiar property of making other gums flexible; it may be added to any spirit varnish, but the amount should not be very large, except in the case of the celluoid varnishes, where it may be 25 per cent of the guncotton. One ounce of camphor to a gallon of shellac or sandarac varnish is sufficient.

Water colors may be mixed with a distemper liquid, without grinding, and produce a very good paint, but are far better when ground.

FORMULAS FOR OIL COLORS.

Oil colors unlike water colors are very unsatisfactory when simply mixed with the paint vehicle, therefore to obtain the best results it is imperative that they be ground in a paint mill before being mixed with the thinners.

The finer the paints are ground, the better the results in regard to covering capacity, hiding power, tinting quality, and durability. Furthermore, coarse pigments settle far more rapidly than finely ground pigments.

In some cases, as American vermilion, the pigment cannot be ground as fine as desired, on account of the crystals being broken and a yellow tone imparted to the paste. Such cases are rare and the beauty of zinc oxide is that it will stand any amount of grinding without being affected.

In grinding, the dry pigment is mixed with a given measure or weight of oil, and the paste is then ground in a stone or iron paint mill.

* Extract from winning paper by W. G. Scott in competition for prize offered by the New Jersey Zinc Company, New York City.

For very fine grinding the mills should be "water cooled" to prevent heating of the paint.

The thickness of the ground paste will depend upon the size and kind of mill used, a large stone mill being able to handle an extra "stiff paste," whereas, in an iron mill it will only be possible to grind what is termed a "medium paste."

A "stiff paste" is generally made in a "chaser" or edge runner machine previous to grinding, while a "medium paste" may be made by incorporating the pigment and oil by agitation or stirring in a "pony mixer."

A stiff mix of white lead or zinc oxide will generally require a 24 to 36-inch stone mill for grinding, whereas in the case of a medium mix the paint may be ground in a 12-inch iron mill.

It is obvious that a stiff paste will contain more pigment and less oil than a medium mix, as shown in the two following examples:

"Stiff or Thick Paste" (large stone mills):

(a) 92½ pounds dry white lead,
7½ pounds raw linseed oil.
(b) 35½ pounds zinc oxide,
7¼ pounds raw linseed oil.

"Medium Paste" (iron mills):

(c) 62½ pounds dry white lead,
7½ pounds raw linseed oil.
(d) 23½ pounds zinc oxide,
7½ pounds raw linseed oil.

It will be noticed that the proportional difference in pigment is about one-third less for the medium mix.

The regular paint grinders use stone mills and turn out thick pastes (unless oil is very cheap).

Of late years many of the large manufacturers of agricultural implements, machinery, etc., have been grinding their own primers and second coat colors, using, as a rule, the less expensive water cooled, iron paint mills.

The regular paint grinder has his own particular lot of formulas, therefore the following formulas are designed for the latter class and the amount of oil is figured for the "medium mix"; if a stiff paste is desired, increase the dry pigment by about one-half.

Laboratory white:

55 pounds pure zinc oxide,
35 pounds lithopone,
10 pounds floated silica,
3 gallons raw linseed oil,
½ gallon white grinding japan,
¼ gallon turpentine.

This paint is unaffected by sulphur fumes, gases, light, air, and ammonia or acid fumes.

It dries with an egg-shell gloss, remains snowy-white and is very durable.

Cheap zinc primer:

69 pounds common zinc oxide,
35 pounds gilder's bolted whiting.
5 pounds floated silica,
3 gallons raw linseed oil,
¼ gallon crystal drier.

This paint is very adhesive and becomes exceedingly hard in time. The silica prevents scaling, due to moisture in the wood.

For dipping purposes, the paste is thinned with benzine, or a mixture consisting of 9 parts of benzine to 1 of oil, until a Baumé hydrometer sinks to about 55 deg. (1.611 sp. gr.).

For one-coat work the hydrometer should stand at about 64 deg. B. (1.790 sp. gr.).

Brush consistency is attained with the following gravities:

Primer = 60 deg. B. (1.706 sp. gr.).
Second coat = 66 deg. B. (1.835 sp. gr.).

The hydrometer generally used is Baumé's hydrometer for heavy liquids, the scale reading from 72 deg. to 50 deg.

With slight variations, all dipping paints may be thinned to the proper consistency by means of a hydrometer.

The paste primer may be tinted any desired color by adding the proper pigment; thus 5 pounds of Venetian red ground with the above, gives a pink primer.

Cheap zinc white:

100 pounds leaded zinc,
25 pounds common zinc oxide.
20 pounds gilder's bolted whiting.
5 pounds floated silica,
5 gallons raw linseed oil.

The above makes a splendid, cheap white paste for second-coat work or mixed paints.

"Eldorado" white:

35 pounds leaded zinc,
55 pounds sublimed lead,
25 pounds common zinc oxide,
3 gallons raw linseed oil.

"Premium" W. G. S. white:

60 pounds white lead (carbonate),
35 pounds common zinc oxide,
10 pounds floated silica,
2 gallons raw linseed oil.

This is one of the most durable whites known, and is superior to any of the single pigment paints ground in oil. The lead gives it toughness, the zinc imparts hardness and purity of color, and the silica renders it porous enough for moisture to escape from the wood.

Zinc roof paint (gray):

25 pounds silver lead (plumbago or graphite),
15 pounds floated silica,
10 pounds common zinc oxide,
3¼ gallons raw linseed oil,
¾ gallon oil drier.

This is intended for metal roofs, shutters, etc.

Elastic ivory white:

50 pounds "Green Seal" zinc oxide,
1 gallon raw linseed oil,
½ gallon nonpareil japan,
½ gallon camphorated turpentine.

This paint dries with a dull luster and is as tough as horn. It is designed for sheet metals subject to a slight bend.

The camphorated turpentine is made by dissolving 8 ounces of camphor gum in 1 gallon of turpentine.

White enamel paste:

30 pounds "Green Seal" zinc oxide,
20 pounds lithopone,
2 ounces ultramarine blue (cobalt blue shade),
1¼ gallons white enamel varnish,
½ gallon bleached linseed oil,
¾ gallon camphorated turpentine.

For use, 48 pounds of the above is mixed with
1½ gallons white enamel varnish,
½ gallon white damar varnish,
¼ gallon solvent naphtha.

Turpentine may be used in place of solvent naphtha if desired, but exerts a flatting effect.

Gloss zinc (in damar):

75 pounds pure zinc oxide,
1 ounce ultramarine blue (cobalt shade),
5 gallons pure white damar varnish,
¼ gallon turpentine,
⅛ gallon poppy oil.

This paint was formerly used as an interior finish, but has been superseded of late by the enamels.

White japan color:

25 pounds common zinc oxide,
25 pounds lithopone,
1 gallon white grinding japan,
¼ gallon turpentine,
⅛ gallon bleached linseed oil.

Japan colors dry exceedingly fast and with a flat surface. For striping purposes the very little grinding japan should contain very little gum, as the gum has a tendency to make the brush "drag" and shortens the length of the line.

The foregoing recipes all call for more or less zinc oxide, a fact which bears out the assertion that no other pigment has such a diversity of uses, and it can be used with impunity in admixture with any and all other colors, and with any kind of a paint vehicle.

THE USES OF SPUN GLASS.

THAT spun glass, long known as a curiosity and more recently employed in making ornaments, or in decoration, will come into wide use for other and more practical purposes, is prophesied by E. Lemaire in La Nature.

In recent years the electrical and chemical industries have made large use of the valuable properties of glass. In the electrical industry its non-conductibility for heat and electricity has been especially useful; in chemical laboratories, its great power of resistance to reagents. Nevertheless, the applications of glass seem not to have been developed to the utmost; and in particular we have scarcely utilized at all its property of being easily spun and of thus entering into the formation of textile fabrics.

Clothing made of such textiles would be incombustible, non-conducting, and resistant to acids, and would be perfectly insulating to electricity. Workmen wearing it would be proof against burns in the metallurgical industries and against injury by acids in chemical works; . . . and finally, in the electrical industries, rubber gloves, when guarded on the outside by spun-glass coverings, would absolutely prevent death from electric shock. The present use of spun-glass fabrics is not wide, but the cause should be sought in the lack of information on the subject in technical literature. Such is the opinion, at least, expressed by Mr. R. Lee in the Elektrotechnischer Anzeiger, from whose article we gather some of the following data.

The art of spinning glass would appear to have been practised by the ancient Egyptians, but it was of little importance until the manufacture of glass was taken up at Venice. By the end of the eighteenth century the spinning of glass had spread through France and Bohemia, where it was long practised by peripatetic artists who frequented fairs and kermesses. It then consisted (and the method of working has not greatly changed since) in melting the end of a glass rod in a flame, grasping it with pincers, and fixing it to a wooden drum, called a lantern, which was turned rapidly while the glass continued to be heated and softened at the end of the rod. The process required great manual skill, attainable only by long practice. The drum was three or four feet in diameter, and as the mass of glass thread rolled thereon was cut across, it yielded pieces about three yards long. Their flexibility was not great enough to fit them for anything but braiding and making lace.

Successful attempts were made in the middle of the nineteenth century by a Frenchman, J. de Brunfaut, with the object of obtaining industrially longer, more flexible, and stronger threads. Brunfaut may be considered the inventor of the modern spun-glass industry, but unfortunately he did not divulge all the secrets of its manufacture. His glass gives on analysis . . . a composition very nearly that of Bohemian glass, which is very hard and resistant to heat and acids. . . . Brunfaut's spun glass is used to make embroidery and passementerie. The industry was once prosperous in France, and Messrs. Dubus and Bonnel were able to weave cloth with the spun glass. At present aigrettes and imitation ostrich feathers are made with it.

The orange-yellow glass yields brilliant tissues that resemble cloth of gold, while the white spun glass imitates silver. These fabrics, despite the transparency of glass, are not transparent, because the index of refraction between the glass and the air interposed between the fibers is too great. To get very brilliant threads with a metallic luster a rod of glass of rectangular section is used. This yields a flattened thread which preserves its four right angles and four plane faces, reflecting the light readily.

De Brunfaut made also a glass cotton . . . which could be felted; his process would seem to have been rediscovered and improved by the brothers Weisskopf, and by the Bohemian Morchenstern.

Doubtless, if a ready sale should be assured, investigations would be made in industrial laboratories to find glasses that would satisfy certain conditions and particularly that would lend themselves readily to weaving; probably industrial processes would then soon be devised to make such spun glass cheaply. However this may be, the uses of spun glass, outside of jewelry and ornamentation, are already quite numerous and merit attention.

Glass-wool, which resembles silk, conducts heat . . . poorly, because of the included air. . . . Tissues are made of it for the wear of gouty and rheumatic persons. The refuse is utilized for packing steam pipes. In Germany the longer fibers are braided into lamp-wicks, which never burn out and act with the greatest regularity. These same braids serve also sometimes for non-conducting envelops, or are used for the insulation of electric conductors; washers for steam joints are made of it and used in the same way as those of asbestos.

Finally, quite recently, the capillary attraction of these fibers has been utilized to hold the acid liquid of so-called "dry" piles of accumulators, especially where these devices are exposed to shocks, as when they are used to light automobiles.

Steam vs. Compressed Air for Power Hammers.—Although compressed air possesses certain advantages over steam for operating power hammers, the sweeping statement sometimes met with that the former is the more economical in steam hammers does not seem to be confirmed upon investigation. Messrs. B. & S. Massey, a prominent English firm of pneumatic and steam-power hammer makers, have recently published tables which throw considerable light on the subject. The properties of steam and compressed air are so nearly alike that it is safe to say that the same amount of work can be done in a hammer cylinder by a given volume of each, measured at the same pressure. From the data in Messrs. Massey's tables it would seem that as regards the cost of power it is more economical to use steam than compressed air. For instance, if the figures for 60 pounds steam pressure be compared with those for 45 pounds air pressure—the latter being regarded by the authors as the most economical air pressure to work at—with reference to a works where coal is obtainable for $2.40 per ton, and electric current costs 2 cents per kilowatt-hour, or belt power 1.76 cents per B.H.P.-hour, the cost will be as 22.6 is to 99; or, stated otherwise, the cost of steam driving will be less than one-quarter of that of air operating. On the other hand, in a works which has to pay $4.20 per ton for fuel and only 0.5 cent per kilowatt-hour for electric energy, or 0.44 cent per B.H.P.-hour for belt driving, air comes out the cheaper (36.6 : 25). Broadly, however, it may be calculated that the cost of driving by steam and air will be about the same in a works where coal costs $6 per ton and electric power 1 cent per kilowatt-hour, or belt power 0.88 cent per B.H.P.-hour. (In these calculations it is assumed that 5 pounds of steam will be delivered to the hammer per pound of coal burned, allowing for average boilers a loss by condensation in pipes of 2½ pounds. Fifty cents per ton is included in the prices given for coal for labor and boiler maintenance.)—The Engineer, London.

A GASOLINE RAILROAD INSPECTION CAR.

AN INTERESTING ENGLISH EXPERIMENT.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

A NEW type of gasoline-propelled railroad motor carriage, especially designed for the use of officials on inspection work, has recently been completed at the York workshops of the North-Eastern Railway of Great Britain for service upon its system. The car is 17 feet in length by 7 feet in width, having a wheel base of 10 feet, and providing seating accommodation for six persons in a central saloon with a driver's compartment at each end. The saloon is entered from either end through the driver's compartment, and in addition to the paramount seating facilities, two extra seats are provided when required on camp stools. The general design and appearance of the vehicle may be gathered from the accompanying illustration, the coach being glazed all round above the waist line, so that an uninterrupted view is secured from the officials' saloon, while the ends and roof are so shaped as to offer the minimum of resistance to the wind.

The propelling mechanism comprises a 35 to 40 horse-power four-cylinder gasoline motor, with cylinders of 4.625 inches bore by 5.5 inches stroke, running at a normal speed of 950 revolutions per minute. The valves are mechanically operated, and the vaporizer is gravity fed. It is fitted with two types of magneto ignition (Eisenmann high tension and ordinary low tension). A forced lubrication system is used, while an ordinary centrifugal type governor is mounted on the exhaust cam shaft.

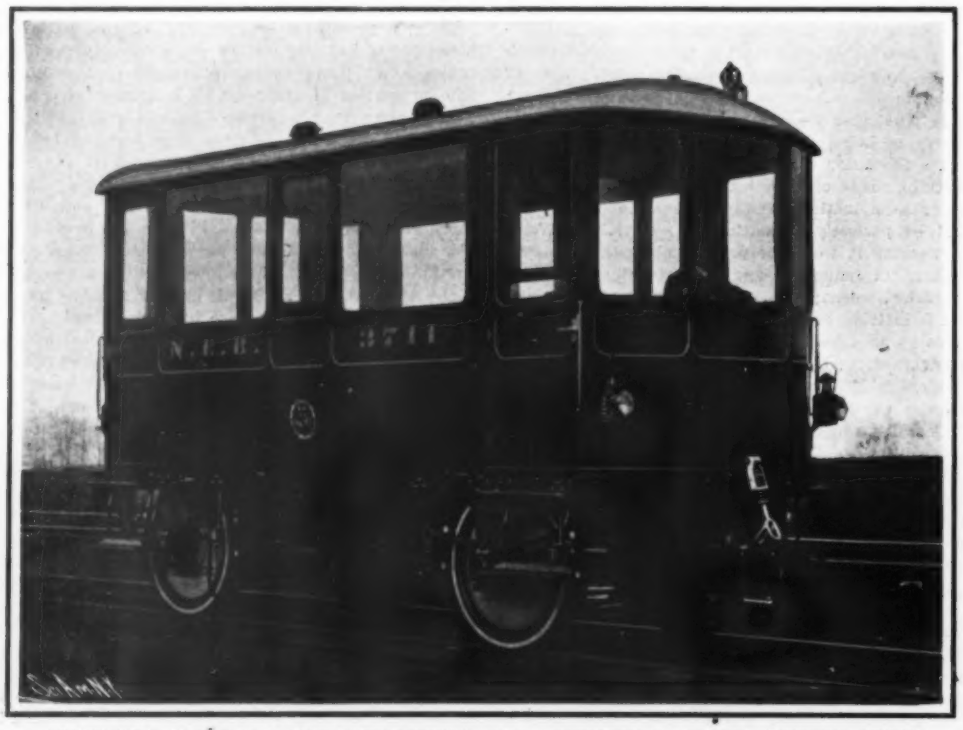
The engine is mounted on an independent frame built up of light steel channels, and carried on inside journals on the axle by means of roller bearings, the journals being 3 inches diameter by 4.75 inches and 2 feet 8.75 inches centers. The center line of the engine shaft is also the center line of the driving axle. The driving wheels have no springs between the axle boxes and the frame, but at the trailing end helical springs are interposed between the trailing axle boxes and the frame. These boxes work in horn plates with a radius described by the wheel base, and take off a considerable amount of shock between the rails and the engine frame.

The gears fitted with rigid shafts are carried in gun-metal bearings fixed to the underframe, and give three speeds in either direction, viz., 15, 30, and 45 miles per hour, the latter being direct from the engine to the bevel gears on the driving wheels. The rotary motion is applied to the driving wheels by a pinion fixed to the end of the engine shaft, and arranged to gear with either of the two large bevels fitted on a sliding sleeve on the driving axle. The center part of the axle is of square section to receive the sleeve and bevels, which give the forward and reverse movements, and are operated from the driver's compartment by a horizontal reversing screw; the thrust necessary to keep the bevels up to the pinion when running being taken by a double ball bearing. The power is transmitted from the engine to the gear through a Hele-Shaw clutch operated by hand levers placed in a convenient position in the driver's compartments, while the gears are also similarly operated.

VIEW SHOWING THE DRIVER'S COMPARTMENT AND PART OF THE SALOON.

The body frame is built up of light channels and angles, and is carried on roller bearings with journals 2.5 inches diameter by 5 inches placed outside the wheels, and is therefore quite isolated from the engine frame, so that any vibration set up by the engine or gears cannot be communicated to the car. Two tanks built into the framing and each of seven gallons capacity carry the water supply of the engine. There is a system of radiating pipes between the motor and the tanks.

The coach is mounted on four Mansell type wheels with wood centers of 3 feet diameter and conforming to the North-Eastern Railway's standard requirements so far as tread and flange are concerned. A hand brake of particularly powerful design operating four blocks on each pair of wheels is placed in the driver's compartment at either end of the car, since it can be driven from either end. Warning and other signals are given by a loud siren coupled to the motor exhaust. The siren may be operated from either driving compartment, while sand can also be similarly applied when required. The body is built of teak with mahogany panels, and with the interior finished in walnut. The saloon is lighted by electricity on the storage principle. The driver's compartments are equipped with speed indicators.



EXTERIOR VIEW OF THE INSPECTION CAR. WEIGHT 6.6 TONS. FITTED WITH A 35-40-HORSE-POWER GASOLINE MOTOR.

In running order the car weighs complete 6.6 tons, including 15 gallons of water and 20 gallons of gasoline. The fuel consumption averages 12 miles per gallon, so that a journey of 240 miles can be completed upon a single tank charge. During the trials the car has covered a distance of over 1,200 miles without a mishap of any description, and speeds upward of 55 miles per hour have been attained. Under all conditions of speed and road, owing to its low center of gravity, the car has proved perfectly steady and comfortable, and it constitutes an excellent vehicle for the work for which it has been designed.

The sand dunes on the coast of France, mainly in Gascony, which the winds drove farther and farther inland, wasting the vineyards, have now largely been fixed in place by forest plantations which were begun in 1793. Of the 350,000 acres of sand dunes 275,000 have been planted in forest, and the dunes, instead of being a constant menace to the neighboring farmers, now are growing crops of pine which produce valuable wood and resin. In all, about $2,000,000 was spent in the work and an additional $700,000 was laid out in bringing the forests under administration. Now, though about one-half of the lands have been acquired by private persons and the State retains only about 125,000 acres, the State has received $120,000 above all expenses, and possesses a property worth $10,000,000, acquired virtually for nothing. Some 2,000,000 acres of shifting sands and marshes toward the interior of the country, a triangular territory known as the Landes, has been changed from a formerly worthless condition into a profitable forest valued at $100,000,000. Reforestation was begun about the middle of the last century. This work was done principally by the communes, aided and imitated by private owners, and encouraged by the State. The resulting forest produces both pine timber and resin, upon the yield of which the present valuation is based.

SOARING FLIGHT.*

MODELS FOR ITS MECHANICAL INVESTIGATION.

BY MARCEL DEPREZ.

I.

THE phenomenon known as the soaring flight of some of the larger species of sailing birds is one that has constantly aroused the wonder and taxed the ingenuity of engineers. Briefly, it occurs in this wise: the bird, with outstretched, motionless wings, remains in absolute immobility at a certain height above the surface of the earth, like a kite anchored by a rope that prevents it from being carried away by the wind which provides its ascensional force. Now the force that supports the bird and prevents it from falling is undoubtedly the same as that which supports the kite; in other words, it is derived from an air-current in which the bird is immersed and which exerts on its wings a pressure that may be resolved into: (1) a vertical component equal and opposite to the weight of the animal, and (2) a horizontal component which, in the case of the kite, is balanced by the resistance of the anchor-rope. Now, as the bird is perfectly free, why is it not carried away by this horizontal component which is increased, moreover, by the pressure exerted by the air-current on the body of the bird?

This problem has been the subject of many controversies which have only resulted in proving the extreme difficulty of finding a satisfactory solution. So great is this difficulty that more than one eminent engineer has recently been known to opine that this soaring flight is a mysterious phenomenon incapable of explanation in our present state of knowledge.

I shall prove that, on the contrary, the explanation is simple and involves no hypothesis that does not lie within the elementary laws of mechanics. In order to solve the problem it will, in fact, suffice to have recourse to a single one of these laws, which relates to the pressure exerted by a gas at rest or in motion, by virtue of which this pressure is always directed normally to the surface on which it acts, provided always that the friction of the gaseous molecules on the surfaces along which they flow is neglected. It is an easy matter to consider this tangential action and to prove that it in no wise invalidates the results obtained from the law of pressure normal to the surface.

With this proviso it is easy to analyze the forces acting on a small plane that represents an element of the wing of a bird placed in a horizontal air-current (directed from left to right), and forming with this current an angle (reckoned in the direction of the hands of a clock) falling between zero and $\pi/2$. It will immediately be apparent that the force acting normally to the plane, due to the pressure of the air current, can be resolved into a vertical force directed from below upward, that is, in a direction opposite to the weight of the bird, and in a horizontal force acting from left to right, that is, in the direction of the air current. The bird, therefore, will be sustained but carried away in the direction of the air current. Therefore, no soaring flight is ever possible if the air current has a strictly horizontal direction.

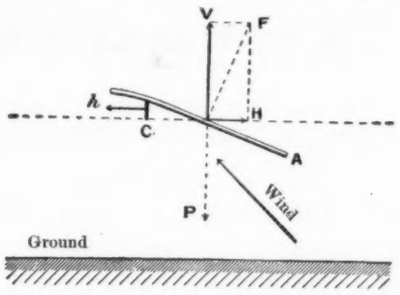


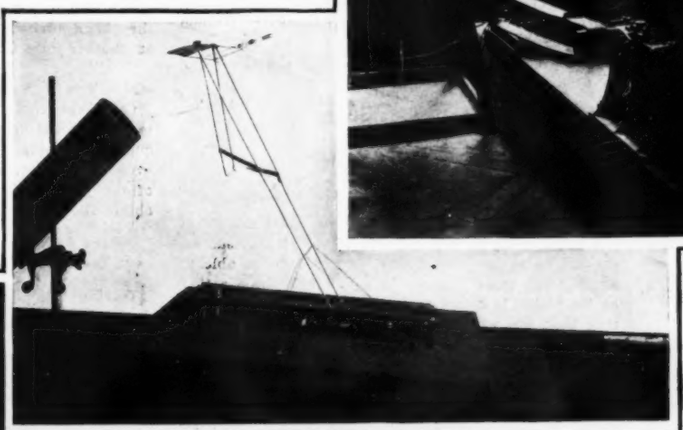
DIAGRAM ILLUSTRATING THE MECHANISM OF SOARING FLIGHT.

Now let us suppose that the air current is given a slightly ascending direction, or, what amounts to the same thing, that it assumes to the horizontal an angle which, reckoned in the direction of the hands of the clock, has a slight negative value, such as ten degrees, and let us likewise give to the plane a negative inclination, but smaller than that of the air current, so that it is situated in the angular space comprised between the horizontal line passing through its center and the straight line representing the direction of the wind and passing through the same center. Then let us, as before, resolve the normal pressure exerted on the plane by the air-current into two forces, the one vertical, the other horizontal. It is straightway apparent that the vertical component is still directed from below upward, that is, in opposition to the weight of the bird, while the horizontal component acts in a direction opposite to the direction of the wind considered horizontally. The small plane will therefore have a tendency to move in a contrary direction to the wind, and if the horizontal force exerted in this manner is balanced by an equal and opposite force due, for instance, to the pressure of the wind on the bird's body, the sum of the forces acting on the small plane is reduced to the vertical component acting in a contrary direction to the bird's weight. We may safely conclude from this analysis that the integral of all these primary forces acting on a bird's wing may be resolved into a vertical force which, if the numerical conditions of the problem (speed and angle of the wind, surface and angle of the wings) are suitably selected, will be precisely equal to the bird's weight, so that the bird, being no longer submitted to the action of any horizontal or vertical forces, will remain at rest in space in the midst of the air current, without need of having recourse to any mechanical work and, consequently, without imparting any movement to its wings. In a word, it will soar.

I have applied these deductions to the action exerted on the concave portion of a curved wing, and have arrived at even more definite conclusions. In the first place I found, as could easily be foreseen, that curved surfaces (such as birds' wings really are) give results that are more pronounced and more varied than planes, and that they lend themselves with more facility to a close numerical calculation of the horizontal and vertical components which can be made to vary almost independently of each other. In a word, curved surfaces are from every point of view indisputably superior to plane surfaces.

Finally I wished to put to the proof of actual experiment the curious but clear conclusions which I have set forth, and so designed a small model for the purpose of showing the existence of the horizontal component working in an opposite direction to the wind when the latter has an obliquely ascending trajectory. It consists of a curved surface mounted on a very light chariot free to move on a slightly inclined plane. When the curved surface has been suitably placed, the air current from a ventilating fan is directed against it and from below, and it is then seen that, instead of being repulsed by the current, the model advances in a direction opposite to the current and rolls up the inclined plane, down which it, of course, returns to its original position when the current is stopped.

APPARATUS FOR PRODUCING SOARING FLIGHT.



THE CAR TRAVELS UP THE INCLINED RAILWAY AGAINST THE WIND.

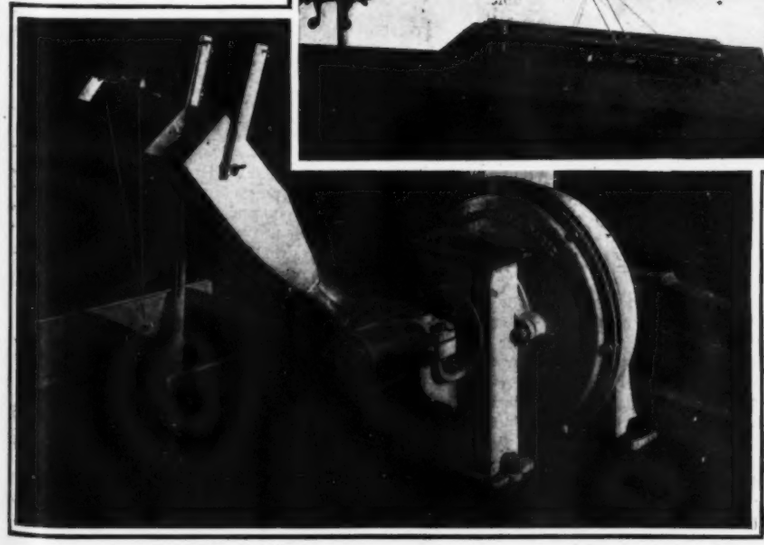
One of the most interesting and important consequences of this investigation is that it proves the possibility of constructing dirigible balloons fitted with sails which derive entirely from the wind their ascensional force and motive power by which they are enabled to move freely in every direction so long as the wind has a slightly ascensional direction.

II.

In the foregoing I have shown that the soaring flight of the great sailing birds admits of a simple explanation, and that the following two conditions are necessary for the realization of this phenomenon:

1. The sum of the vertical components of the wind pressure on the bird's body and on its wings must be equal to its weight.

2. The sum of the horizontal components of the wind pressure, measured on the bird's body, must be equal and of opposite sign to this



UNDER THE INFLUENCE OF THE CURRENT OF AIR BLOWN FROM THE FAN THE LITTLE ALUMINIUM BIRD SOARS MECHANICALLY.

SOARING FLIGHT.

*From Comptes Rendus, cxliv, 15 and 20.

sum measured on the wings, so that the algebraic sum of all the horizontal components acting upon the entire bird (body and wings) should be zero. It follows from this condition that the sum of the horizontal components affecting the wings alone must act in the opposite direction to the horizontal component of the wind velocity.

I have shown that, in order to explain soaring flight, the absolute necessity of admitting that the motionless wings of the bird are acted upon by a horizontal force contrary to the direction of the wind (reckoned horizontally) proves that the direction of the wind cannot be horizontal, but that it must have an ascending tendency.

I further stated that the curve in the wing surfaces of the bird greatly facilitated the production of the negative horizontal component of the wind pressure, and that the approximate calculation of this component (and of the vertical component, for that matter) was relatively much simpler than seemed likely from the rudimentary state of our knowledge concerning the laws governing the action of a fluid in motion on a surface which is not normal to the direction of the stream lines, even when it is a simple plane.

Moreover, apart from the formulæ I have established, which are not applicable in the case of a curved surface save when the wind is almost tangential in effect, I have devised a graphic method for showing immediately in a striking way how easily one may obtain, with a curved surface, the negative horizontal force necessary to support the bird motionless, and this independently of the direction and speed of the air current on the various points of the wing surface.

I will state some of the consequences of my theory:

1. The velocity of the wind has no influence whatever on the horizontal equilibrium of the bird; in other words, the horizontal equilibrium which has been established for a given velocity of the wind remains if the wings retain their position when the velocity of the wind changes. But not so with the vertical equilibrium.

2. The shape of the rear portion of the bird's body and of its tail helps to create a negative horizontal force which is added to that of the wings.

3. The ascending inclination of the wind necessary for soaring flight diminishes in proportion as the surface of the wings increases relatively to the master diameter of the bird's body.

RATING AN AUTOMOBILE ENGINE.

DETERMINING HORSE-POWER FROM THE CYLINDER DIMENSIONS.

BY THOMAS L. WHITE.

THE problem of rating a car is one which is of equal interest to the manufacturer who makes it, the engineer who designs it, and the layman who buys it; but it is especially to the last that this article is addressed, the aim being to explain the broad principles by aid of which the horse-power of a motor can be determined from the cylinder dimensions, rather than to add still another to the numerous rating formulæ already in existence.

The power of an automobile motor, or in fact of any engine, is measured by the amount of work that it can render in a certain time. It is a *rate*, and as such cannot be dissociated from the conception of a definite period of time during which a certain task is performed. It must not be confused with the idea of pressure or torque or thrust, nor with the degree of magnitude of any of these.

Since power implies so much work per minute, to use the unit of time which custom has decreed as most convenient, the mathematical determination of power involves the determination of work, and in the exact engineering sense of the term work means motion against resistance. It is measured by the product of the resistance and the distance through which it is overcome, or what is the same thing, by the product of the acting force and the distance through which it acts. The engineering unit of work is the work done in lifting a mass of one pound through a vertical distance of one foot against the resistance exerted by the attraction of the earth. It is called a foot pound, and it will be noticed that there is no element of time involved in its conception. Work is not a rate, and the energy expended in overcoming a certain resistance through a certain distance is independent of the elasped time necessary for the operation.

In measuring the work done by engines, the foot pound is inconveniently small, and engineers have adopted the estimate made by Watt of the power of a horse, viz., 33,000 foot pounds per minute, as a more suitable standard. This is known as a horse-power, and the power of engines is expressed in terms of this unit.

The internal combustion engine may be defined to be an instrument by which the energy or capacity of doing work stored up in fuels is transformed into the heat energy of expanding gases, and finally into useful mechanical work done against resistances. In this transformation, or rather series of transformations, there are three coefficients or multipliers, by which the total number of heat units liberated during the combustion of the fuel must be multiplied in order to arrive at the number of foot pounds in the useful output of the motor.

The first is the mechanical equivalent of heat, and if we denote its value by the symbol x, then x times the number of British thermal units liberated by the combustion of a stated weight of fuel is the number of foot pounds of work that the motor would be capable of turning out if the energy of the fuel were completely reproduced in useful effect at the crankshaft.

The second is the thermal efficiency of the engine. If we denote it by y, then y times the last product is equal to the number of foot pounds actually delivered by the expanding gases on the piston against the friction and inertia of the engine and against the resistance of the load. For most gasoline engines y lies between 10 per cent and 20 per cent, and the last product is the one which enters into the determination of the nominal horse-power of the motor.

The third multiplier may be called the mechanical coefficient, and it corresponds to the *pro rata* loss between the piston and the crankshaft. If we denote this quantity by z, we have for the whole process, taking the number of heat units in a pound of gasoline as 19,000, a final output at crankshaft of $19{,}000xyz$ foot pounds per pound of gasoline consumed. This, the third quantity derived from the original calorific value of the fuel, bears the same relation to the brake horse-power that the second bore to the nominal horse-power.

Neither of the last two results, which represent actual transformations of energy, affords any indication whether the effect is obtained in a thousand strokes or in ten thousand, or whether those strokes, whatever be their number, are quick or slow. In other words, the results afford no information of a direct character as to the power of the motor, that is to say, the rate at which it is working; and in order to proceed, it is now necessary to consider the unit effort of the engine, of which its total effect is merely a multiple, viz., the expansion stroke.

When the explosion takes place in the cylinder of a motor, the energy liberated is associated with a rise in pressure, and the force exerted by this increased pressure impels the piston forward. In order to understand what follows, it should be carefully noted in this connection that a pressure is not a force any more than a velocity is a length. A pressure is so many units of force acting per unit of area, say ten pounds per square foot, just as a velocity is so many feet passed over per second; and in exactly the same way as by multiplying the time and the velocity together we get the distance traversed, so by multiplying a pressure by the area on which it is exerted, we get the total force which is its effect. Bearing this in mind, if we suppose that the pressure of the explosion in the combustion chamber is p pounds per square foot, then the piston at the beginning of its motion has impressed on it by the expanding gases a force of $p\,A$ pounds, where A is the area of the piston head expressed in square feet. Now, in order to be able to analyze the exact manner in which this force acting on the piston is doing work, we will make the supposition that the whole distance through which the piston travels is divided into n equal parts, n being very great, so that each of the subdivisions into which the total piston travel is divided is small enough for the pressure exerted by the expanding gases while the piston is passing over a given subdivision to be regarded as appreciably constant, though less than the pressure in passing over the previous subdivision and greater than the pressure in passing over the next succeeding subdivision. If the total piston travel be S feet, it is clear that the length of each of the subdivisions is S/n.

If we further suppose that the pressure while the piston is passing over the first subdivision is equal to p pounds, over the second to p' pounds, over the third to p'' pounds, and so forth, then it is clear that the work done while the piston is passing over the first subdivision is pAS/n, this being the product of the force pA and S/n, the distance through which it is exerted. Similarly, the work done while the piston is passing over the second subdivision is $p'AS/n$, over the third subdivision is $p''AS/n$, and so on, the total work done during the expansion being equal to the sum of these instalments into which we have considered it to be divided up, that is, to—

$$pAS/n + p'AS/n + p''AS/n +, \text{ etc.},$$

which equals

$$AS/n\ (p + p' + p'' +, \text{etc.}),$$

which can be written

$$AS \cdot \frac{(p + p' + p'' +, \text{etc.})}{n}$$

Now the last factor in the last form of the expression for the total work is the sum of the successive pressures exerted during the expansion divided by their number, that is to say, that it is the *mean* or *average pressure*, and we have as our final result as the whole work done on the piston during the expansion stroke,

$$ASp_m \text{ foot pounds,} \qquad (1)$$

where p_m is used to denote the mean pressure exerted by the expanding gases. It should be noticed that this expression is independent of n, the number of parts into which the length of the stroke was supposed to be divided. It follows that result (1) would have been the same had n been infinitely great, in which case our assumption of the pressure descending by a series of small differences would, instead of being an approximation, have been an exact representation of the continuous fall of pressure which in reality occurs in the cylinder during the stroke.

Result (1) is fundamental, and enters into all determinations of nominal horse-power. It can be written in several ways, or rather it is susceptible of several interpretations. Thus AS is the piston clearance or cylindrical volume of the motor, the portion of the whole volume of the cylinder which is swept out by the piston during the stroke, and we accordingly have as another form of the total work of the expansion,

$$V p_m \qquad (2)$$

where V is the volume in question in cubic feet.

Or, again, the same result may be expressed so as to bring in the diameter of the cylinder. If this latter quantity be equal to D feet, then for A in formula (1) we can substitute $\pi D^2/4$, which is the area of the face of the piston calculated from the diameter, and we obtain the alternative formula,

$$\frac{\pi D^2 p_m S}{4} \qquad (3)$$

Having established expressions for the work done during one working stroke in terms of the cylinder measurements and the mean pressure, the next thing is to consider the work done during one minute. It will be remarked that this manner of considering the output evades any difficulty which may arise from the fact that the work of an internal combustion engine is intermittently rendered, there being in the case of the usual four-cycle motor one working stroke to every two revolutions of the crankshaft. If we denote the number of revolutions by w, then the number of working strokes per minute is $w/2$, and the total work done on the piston in the same time is,

$$\frac{V p_m w}{2} \qquad (4)$$

$$\frac{A S p_m w}{2} \qquad (5)$$

$$\frac{\pi D^2 S p_m w}{8} \qquad (6)$$

according to the form for the work during one expansion which it is most desirable to use. It should be noticed that the results (4), (5), and (6), in that they are each equal to a certain amount of work done during the unit of time, express the nominal power of the motor in foot pounds per minute, and any one of these expressions divided by 33,000 will give a quotient which is equal to the nominal horse-power of the

motor for the particular value of w at which the motor is running.

We have already seen that the work done by the explosive force on the piston of a motor is equal when multiplied by z, the mechanical coefficient, to the net work rendered at the crankshaft. This last quantity may be directly measured by applying to the rim of the flywheel a frictional resistance sufficiently great to hold the engine down to a constant number of revolutions per minute. Let F be the magnitude in pounds of this force, and let L be the flywheel radius. Then it is clear that the distance through which the force F acts during one revolution is equal to $2\pi L$ feet, this being the circumference of the flywheel, and that consequently the work done by the engine against the frictional resistance is $2\pi LF$ foot pounds during one revolution, or $2\pi wLF$ foot pounds per minute. We thus have two expressions for the power of the motor at the crankshaft, both expressed in foot pounds per minute, and equating them we get

$$2\pi wLF = \frac{zwp_mV}{2}$$

or dividing out by $2\pi w$,

$$LF = \frac{zV}{4\pi} \cdot p_m \qquad (7)$$

The product LF is known as the motor moment or torque, and the last equation is an expression of the fact that in a given motor the mean pressure on the piston is directly proportional to the torque exerted on the crankshaft. Also, since it is evident, other things being equal, that the explosive force is proportional to the density of the mixture, that is to the weight of mixture per cubic foot of cylinder volume, equation (7) also proves that for the same motor the density of the mixture bears a constant ratio to the motor moment.

In coming now to apply the formulæ which have been established to the problem of comparing the horse-powers of different motors, it will be necessary to change our view of the constancy of the quantities which enter into them. So far our assumption has been that V, D, A, and S are constants and w and p_m variables. For instance, we have virtually regarded expression (4) as a statement that the volume cleared by the piston being constant, the nominal power is proportional to the mean pressure multiplied by the number of revolutions per minute. The formulæ are, however, susceptible of being interpreted in another way. Let us consider the case of two motors of different volumetric capacity, which are running at the same number of revolutions and in which the mean pressures developed by the explosions are the same. Then we have,

Power of the first motor : Power of the second motor

$$:: \frac{wp_mV}{2} : \frac{w'p'_mV'}{2}$$

$$:: V : V'$$

since wp_m is equal to $w'p'_m$, the dashes indicating that the quantities to which they are affixed have the same significance for the second motor that the plain symbols have for the first. But this is the same thing as saying that if we denote the nominal horse-power by P, so that

$$P = \frac{wp_mV}{2} \qquad (8)$$

then, p_m and w being constant, the power P is in constant proportion to the volume. This hypothetical case is typical of similar comparisons, and we shall now cease to consider the dimensional quantities as fixed and the mean pressure and speed as varying, taking the opposite view that the mean pressure and speed or their product or some simple relation between them are constant and that the dimensional measurements have the nature of variables. The values of p_m and w which will be considered will be those corresponding to the maximum power of the motor in question, and our connecting link, so to speak, in passing from one motor to another will be the experimental fact that the mean pressures and velocities of different motors are for maximum powers simply related in a way which is independent of volumetric measurements.

When a motor is accelerated, the amount of frictional resistance that it is necessary to apply to the flywheel in order to take up the load becomes less and less as the angular velocity increases, and a point is at length reached when a further increase in the number of revolutions no longer produces a net increase in the power. In other words, it is an experimental fact that the expression $2\pi wFL$ has a maximum value which divided by 33,000 is the maximum brake horse-power of the motor. It is the derivation from the corresponding expression $\frac{wVp_m}{2}$ of a corresponding maximum value, which shall only involve dimensional quantities and which shall be independent of the mean pressure and of the speed, which constitutes the problem of rating. Of course, if every engine could be put on the testing stand, and a table of values of the left-hand member of equation (7) computed corresponding to the various values of w, any other determinations would be unnecessary; but there are many contingencies where it is important to know the maximum power of a motor and where a practical test is out of question, and it is to meet the requirements of such cases that a rating is designed.

By writing equation (8) in the form

$$\frac{P}{V} = \frac{wp_m}{2}$$

it is clear that if the value of p_mw is the same for all motors when they are developing their maximum power, then that maximum power will be in the proportion of the piston clearance, that is to say, the maximum number of foot pounds of which the engine is capable per cubic foot of piston clearance will be constant and independent of the motor dimensions. Let us see how this hypothesis squares with the facts, interpreted in a liberal spirit, for it is never possible to say of two engines that they are equally well disigned or that they can be tested under exactly the same conditions.

The subjoined table gives the stroke, bore, piston clearance volume, maximum brake horse-power, and the number of revolutions at which it was delivered, of ten representative motors. In volumetric capacity they cover a range from one to fifteen liters, and they were selected from a much longer list compiled by Arnoux, a French engineer, the principle of the selection being to retain only those motors which for their size were the most powerful. The motors were all of the four-cylinder type, and the values of V given in the table are the total capacities of all four cylinders. The metrical measurements have been retained as being more convenient for manipulation.

Motor.	D	S	w	$H.P.$	V	P/V	p_m
	mm.	*mm.*					
1.....	65	70	1,600	12.5	928	13.5	8.4
2.....	85	90	1,600	22.5	2,042	11.0	6.9
3.....	100	105	1,500	33.5	3,300	10.1	6.7
4.....	120	122	1,350	52.0	5,522	9.4	7.0
5.....	130	128	1,350	60.0	6,798	8.8	6.5
6.....	140	138	1,400	76.0	8,501	8.9	6.4
7.....	150	148	1,400	90.0	10,466	8.6	6.1
8.....	165	155	1,200	110.5	13,262	8.3	6.9
9.....	170	165	1,200	120.0	14,986	8.0	6.7
10.....	180	160	1,300	135.0	16,293	8.3	6.4

The column headed P/V gives the maximum horse-power per liter of piston clearance. The numbers in the last column are proportional to the mean pressure in whatever unit this latter may be expressed. They are derived from equation (8) by substituting the known values of P, V, and w.

The immediate inquiry is whether it is admissible to consider p_mw as constant, and a glance at the P/V values, which are proportional to this product, will show that instead of being independent of the dimensional measurements p_mw decreases as the motor grows bigger. If we assign to it a value which will give a correct volumetric power for motors of moderate capacity, then for large motors we shall derive a horse-power which is much too high and *vice versa*. Without trying to evade the conclusion that the volumetric power of motors decreases with their size, let us take a mean value of 9 horse-power per liter of piston clearance, this being the average of the last nine motors in our table, and test whether the ratings obtained on this supposition depart very far from their experimental values. We have, then:

Motor.	Calculated Rating.	Error. Per cent.
2.....	18.4	18
3.....	29.7	11
4.....	49.7	9
5.....	61.2	2
6.....	76.5	1
7.....	94.0	4
8.....	119.5	8
9.....	135.0	12
10.....	146.7	9

And it appears that except for the fact that the first two motors are considerably underrated, the results derived by taking P/V as equal to 9 are fairly accurate. The equivalent American rating would be 1 H.P. per 7 cubic inches of piston clearance.

The column of mean pressures in our table shows that although there is a slight uniform decline in the value of p_m, yet the average value for the last nine motors, which is 6.6, is very close to the actual value in any particular case. If we assume that p_m is constant for all motors when they are delivering their maximum power, then the power of any given motor would be as the product of the R.P.M. rate and the piston clearance volume. The average value of w for over one hundred tests made by Arnoux was 1,300, and if we take this figure as a mean, we obtain an average value of P/V for all motors of $1,300 \times 6.6$ or 8.6 which does not differ materially from the value 9 which we derived from our table of ten selected motors.

Much labor has been devoted by various investigators to the derivation of rating formulæ of the form $k\,D^n$, where k is constant, and n lies between 2 and 3. Whatever be their merit from a technical point of view, such formulæ, necessitating the use of logarithms for their application, lack the element of simplicity, which, at any rate from the point of view of a layman, is, next to accuracy, the first desideratum in a rating rule. Moreover, such formulæ have no special claim to mathematical exactitude. They are derived by plotting the data from tests in the form of curves, the objects being to construct a mean or average curve, whose equation will serve as a relation between P and D.

The fact of the matter is that no great variety of hypotheses about the relations of w and p_m is possible. We can assume the constancy of p_m, or of w, or of p_mw or we can assume that the piston velocity is constant, which necessitates the constancy of wS and gives from formula (5) a rating depending on D^2. We shall not, however, consider these departures, as they involve nothing new in principle which has not been analyzed when we were deducing a relation between the power and the volume, and the aim of this article being not to criticise rating formulæ, but to outline the reasoning on which they are based.

THE SYNCHRONOUS CONDENSER.

PROBABLY of all of the characteristic performances of the synchronous motor, none is more interesting than its operation as a "condenser"; that is, its tendency to draw leading wattless current from the supply system when its field current is increased above that value giving minimum armature current. Although the machine possesses this tendency to a marked extent, it exhibits few of the characteristics of the apparatus known as a stationary condenser. For example, when the machine is operating as a synchronous condenser, an increase in the supply E. M. F. results in a decrease in the leading wattless current in its armature, while a stationary condenser takes a leading wattless current which continues to increase in value as the supply E. M. F. is increased. The condenser action of a synchronous motor can conveniently be investigated by neglecting momentarily certain minor modifying influences. With a degree of accuracy amply satisfactory for practical purposes, it may be said that throughout its working range the wattless component of current in the armature of a synchronous motor varies directly with the change in the field current from that value which causes the counter E. M. F. of the armature to equal the E. M. F. impressed upon the armature leads. This action is attributable to the demand for a counter E. M. F. equal to the impressed and therefore for a relatively constant field magnetism independent of the value of the field current. The excess or deficiency in magnetomotive force supplied by the field circuit ampere-turns above or below that necessary to maintain the required field magnetism is supplied by a wattless leading or lagging component of the armature current. The latter component may be considered as a "condenser" current having either a positive or a negative value according to whether the field current is above or below that value which causes the condenser current to reduce to zero.

It is worthy of note that the exact amount of change in power factor is not always a true measure of the advantage of eliminating wattless currents from a transmission system. For example, it might seem that a change that would result in increasing the power factor from 78 per cent to 95 per cent is far preferable to a change that would increase the power factor from 95 per cent to 100 per cent. However, the former change indicates the neutralization of the same value of wattless current as does the latter change, and in many cases the detrimental effect of operating a low power factor varies directly with the value of the wattless currents present in the system rather than with the difference between the actual power factor and 100 per cent.—Electrical World.

On May 15 there was held in Cracow, at the Academy of Sciences, a celebration of the twenty-fifth anniversary of Prof. Ilszewski's work on the liquefaction of gases, his first researches in that direction having been commenced during the spring of 1883 with the late Prof. Wróblewski. The celebration was an unofficial one, and only the members of the mathematical and natural history class of the academy took part in it. The president of the academy, Prof. Count Tarnowski, congratulated Prof. Olszewski in an address, after which an album containing photographs of the members of the mathematical and natural history class was presented to him. As the intention of the academy to celebrate the work of its distinguished member was not publicly made known, only a few letters and telegrams reached him, including those of several societies in Warsaw and of the professors of chemistry and of physics in the University of Fribourg.

MONEY AND MONEY-MAKING MACHINERY.*

HOW THE INTRICATE DESIGNS OF BANK NOTES ARE PRODUCED.

BY CLAUDE E. HOLGATE.

In a general way, every one knows that our so-called paper money is made at the Bureau of Engraving and Printing, at Washington, but it is safe to say that very few outside of those directly connected with the industry know that practically all of the important machines used in bank-note engraving, not only in the United States, but all over the civilized world, are supplied by less than half a dozen concerns in Newark, N. J.

MACHINES FOR GUMMING POSTAGE STAMPS.

MACHINES FOR NUMBERING BILLS

The office of the Bureau of Engraving and Printing is to design, engrave, and print all the obligations of the government of the United States, including the interest-bearing bonds, the treasury notes, the national bank-notes, and the gold and silver certificates; also to design, engrave and print the customs and internal revenue stamps, postage stamps, and checks and drafts used in the different departments of the government.

Until recent years, the postage stamps were printed by private bank-note companies, who were the lowest bidders in competition with the Bureau of Engraving and Printing. The Secretary of the Treasury selects the subjects which appear on the face of the government money and securities. Only the portraits of departed citizens who have won distinction are used. Living subjects are not reproduced in the design. The designs are made under the supervision of the Chief of the Engravers' Division of the Bureau, and all are subject to the approval of the Secretary of the Treasury. The designs on the government money are engraved on steel dies. The complete design for the engraving having been selected, a corps of engravers begins work on the different parts of the design. One engraver may work upon the portrait, one upon the lettering, and others upon the ornate work. The engraving of an entire design is never intrusted to a single person, and the whole design is never made upon a single plate, but in sections. When the engraving on the different sections is completed, the dies are hardened and tempered. Sectional rolls, of soft steel, are then passed over the hardened dies by pressure, and the design is transferred in relief to the roll. Each sectional roll bears a part of the complete design. The whole design is then transferred to one piece of steel called the bed-piece, from which a complete roll is made. The finished roll is then tempered and hardened, and four notes are transferred to each plate. This plate is also hardened, and is then ready for the printer. When the complete roll and the printing plates are worn out, recurrence is had to the original rolls, and when these rolls are unfit for further use, the original dies are brought into requisition for the production of new rolls and plates. Rolls and plates are hardened by the cyanide of potash process.

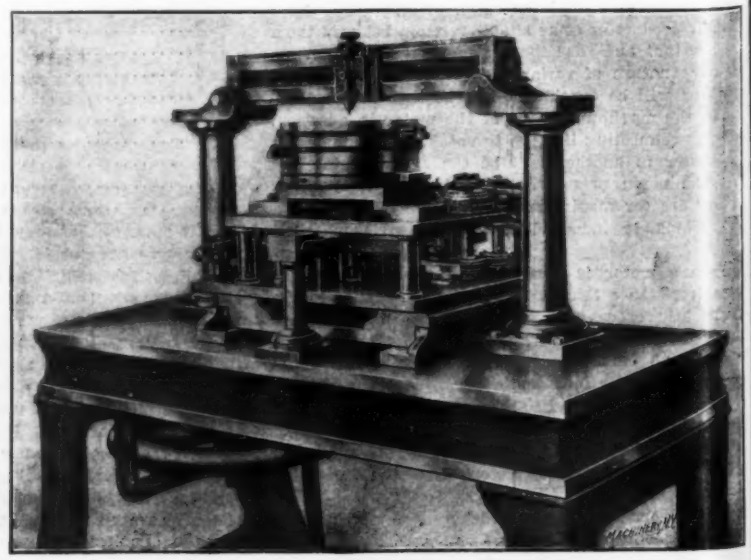
The paper money of the United States, when it is new and fresh from the press, is the finest in the world, and its production is the most expensive. The paper used is made expressly for the Bureau of Engraving and Printing, and directly under its supervision. It is composed of fine linen and silk, and a collection of silk fibers runs lengthwise through the sheets. The process of its manufacture is known only to the manufacturers and the officers of the Bureau. Heavy penalties are imposed merely for the act of having the unprinted paper in possession. The commercial bank note companies have the government's sanction to use a security paper, made by the same mills, in which planchettes or small pieces of silken fiber are interwoven in the texture of the paper during manufacture, but they are not permitted to use the kind employed by the government in the making of money.

CUTTING THE BILLS APART BY MACHINE.

All of the engraving on the plates used is hand work, with the exception of the fine scroll or lace work, which is done by a triumph of mechanical ingenuity known as the geometric lathe, and a cycloid ruling machine for the straight work. Most of the engraving on the back of the different denominations of paper money is the work of the geometric lathe. As these

* Machinery.

A MILLION DOLLARS IN PAPER MONEY READY TO BE DESTROYED.

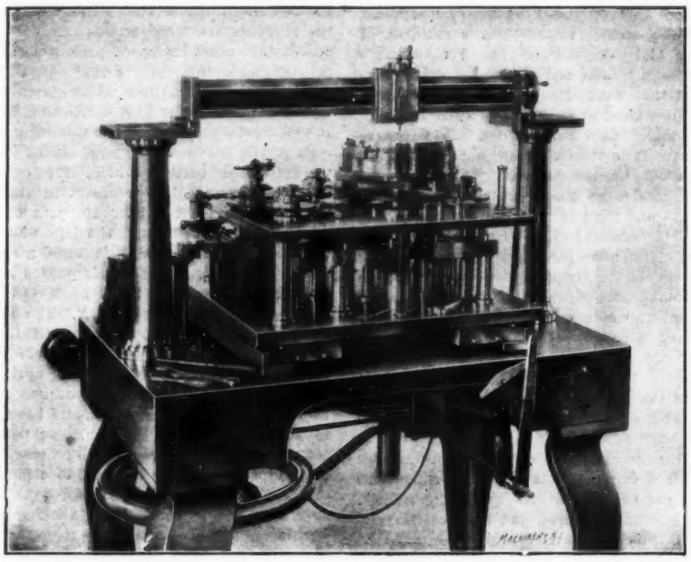


CHAPMAN GEOMETRIC LATHE.

machines cost over $5,000, and as it requires an expert mathematician to operate them, it will readily be seen that the work of the counterfeiter is much embarrassed by its operation.

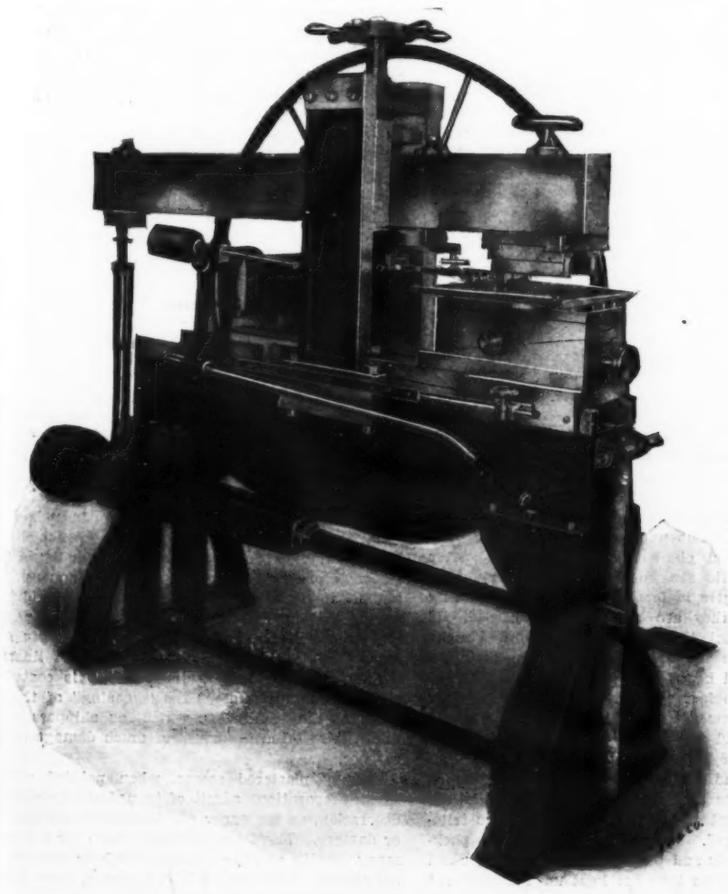
ORIGIN OF THE GEOMETRIC LATHE.

The first geometric lathe was invented by Charles W. Dickinson, who died in 1900, and whose business is now carried on by his son, C. W. Dickinson, Jr., at Belleville, a suburb of Newark. Mr. Dickinson, the senior, was employed as a watchcase maker, and became interested in fine machinery. "Engine-turned" watch cases began to be the style, and he made his first lathe for the purpose of decorating a watch case. This was a success, and a jeweler asked him to make a machine to cut a die which could be used to decorate an oval silver salver. The salver was thirty-four inches long, and the pattern was to follow its general form in one continuous figure or set of interlaced lines. This necessitated new motions being added to the machine, the one he then had being arranged for circles only. Mr. Dickinson made the machine and it was a great success. Later a man wanted a machine to make the curved combinations on bank-notes. A thousand dollars was deposited as a guarantee, and the machine was made. Notice was sent to the individual ordering it when it was completed. Nothing was heard from him, however, and the lathe was sold to someone else. Three years afterward this man was one of a gang arrested for counterfeiting. This gave Mr. Dickinson an idea of one great use for his lathe, and the present geometric lathe, to which improvements have been added from time to time, is the result. The first one was used upon bank-note plates in 1862. Mr. Dickinson went to Washington to run the lathe he had built for the government, and stayed there a year and a half, cutting new combinations for the currency then in use, until he had succeeded in instructing some one in the intricacies of running the lathe. The geometric lathe complete is one of the finest pieces of machinery in existence. It is constructed of a number of superimposed flat plates, accurately hand scraped to surface-plates, which are actuated by cams and gearing, and these are as near perfection as it is possible for human endeavor to get them. It requires four men, about five months, to build one of these lathes, and as infinitesimal accuracy is required in laying out the work and fitting the various movements together, only the most skilled mechanics, who have had years of experience in building this class of machinery, are employed in the work. The accuracy required will be appreciated when it is known that this machine will produce lines so close together that they can be counted only with the aid of a microscope. In the finer engraving, it is possible to work within a twelfth of one-thousandth of an inch. The lathe produces an almost endless combination of geometric figures, by means of combinations of gears, cams, and eccentrics. Over twenty million different patterns have already been counted off, and the end is not yet reached. In fact, with his latest improved lathe, shown on this page, Mr. Dickinson claims to be able to get almost any movement.

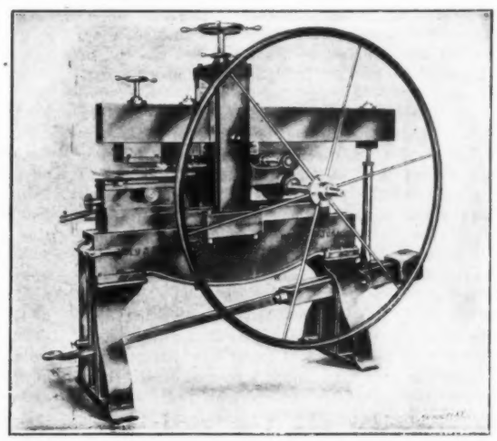


IMPROVED DICKINSON GEOMETRIC LATHE.

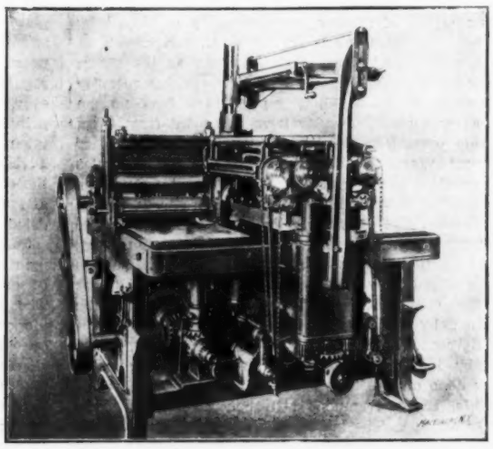
At the corner of a treasury note, the figure denoting its denomination rests upon an ornate design in the shape of a heart, trefoil, a hexagon, an oval, or some other design composed of wave lines finer than hairs. Down in the corners you will find the words "five," "two," or the letter "V" or figure "2" printed upon the same little lacy figure made up of the finest lines. Turn the bill over and you will find the lacy figures repeated in groups or borders, almost entirely covering the back. Look at the little green band around a box of cigars or a bag of tobacco, and somewhere upon it appears similar combinations of circles and wave lines. Every treasury note, every revenue stamp, postage stamp, bank bill, or bond carries these fine-lined creations, and each of a different combination so as to make it difficult to counterfeit. In fact the design in each corner of the face of every bill is different, thus multiplying the difficulty. The die to be engraved is clamped to the top platen or chuck of the lathe. The hardened steel cutting tool—sometimes pointed with a diamond—is fastened in a stationary position on the cross-beam shown at the top of the lathe. The working of the lathe is like fairy fingers. There is no noise—only a slow movement or series of movements of the platen holding the die. The die follows the directions necessary to produce the pattern. Each pattern is calculated mathematically from the degree of a circle. Sometimes it will take two months to make a shell or die of the most intricate patterns. Ordinarily it takes four or five days to complete one of the small designs in the corner of a bill. Not only is the distance from each line measured, but the depth to which the tool is to go. The cutting tool is adjustable vertically, and after a given series of movements



CHAPMAN TRANSFER PRESS.



GOULD-EBERHARDT IMPROVED TRANSFER PRESS.



GOULD-EBERHARDT STEAM POWER PLATE PRINTING PRESS.

MONEY AND MONEY-MAKING MACHINERY.

is completed, the tool is adjusted and a deeper cut taken. The average number of cuts on each movement is about twenty. Having had one row or thread of the figure cut upon it, a shadow of change in the adjustment of the lathe is made, and now the movement may perhaps be from the center to the rim of the design, in and out, over and over again. There are only about twenty of these lathes in existence, and they are owned by the United States and foreign governments, or by the bank-note companies, and it is safe to say that they are the product of either the Dickinson shops, or those of the W. H. Chapman Company, which are also located at Newark. It is unnecessary to add that the U. S. Secret Service keeps a close watch on where new lathes go, as well as the plates that are turned out on them.

While the operator of the geometric lathe has been turning out his lacy designs, the hand engravers have been busy with the portrait work and lettering, and when all the separate dies are completed they are ready for the transferrer, whose methods of operation are described in the fore part of this article.

THE TRANSFER PRESS.

The transfer press, which is used for transferring the separate designs from the dies to the soft steel rolls, and thence back to the flat plates as a completed design, is an important machine in this work. It not only is an aid to the government in its policy of having each part of a treasury note engraved by a separate person, but on bonds and other work of this character it effects a wonderful saving in time, as it enables several engravers to work on various parts of a design at one time; these are then assembled by means of the transfer press into a complete design. It would take a great many months to complete a design if the original engraving were all done on one plate, and each engraver would be required to wait for the other to finish before he could start on his part of the work.

The transfer press is designed on the compound lever principle, as will be noted on referring to the illustration. The engraved die, and the roll which is to receive the impression, are set square with each other by means of a very delicate and accurate gage seen at the front end of the large beam at the top of machine. Then the foot lever which extends under the bed of the press is depressed and the operator, or transferrer as he is called, racks the die back and forth across the surface of the roll through the medium of the large hand-wheel on the side of the press. The shaft on which this hand-wheel is keyed carries a spur pinion on its inner end which meshes with a rack in the bed of the press. With this style of press and its system of compound levers, great pressure can be produced, the ratio between the end of the foot-lever, where the initial pressure is applied, and the end of the beam where the roll is placed being about thirty-five to one.

At one time the government manufactured its own presses. Castings were made under the directions of the Bureau, and put together by machinists in their employ. This policy, however, was abandoned several years ago, and the government now purchases new presses when needed. Some of the first transfer presses were made by Poole & Hunt, of Baltimore, but in later years nearly all of the presses used by the bureau and the bank-note companies have been manufactured by either W. H. Chapman Company, or Gould & Eberhardt, of Newark. The latter concern has made a number of valuable improvements in the press, some of which have been patented. The original design of the press has been made more stable in construction, and more convenient for the operator, and their type of transfer press is used by the government in issuing its specifications for new machines.

THE PRINTING PRESSES.

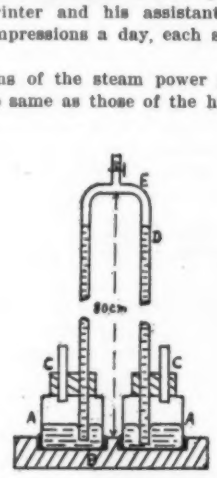
Two styles of presses are commonly employed by the plate printers for their flat work, one known as the D-roller hand press, and the other as the steam power plate press. A new press, however, has recently been designed, by which it is possible to bend up the engraved plates in circular form and print from them on this press very much like the ordinary cylinder presses. While the commercial bank-note companies find occasion to use a great many of the steam presses for their bond work, lithographing, etc., and while the government also uses them for some of its work, for the finer work the government prefers the hand press, of which there are several hundred in use. It was long contended by expert engravers and printers that the fine effects attained by hand work could not be obtained by the steam presses, however ingenious.

This contention, however, has been disputed, and a test by inspection was made several years ago, of work done on the two styles of presses. As a result of this, the government still continues to use the power presses. The law governing the printing of the United States money requires that it be done "in the highest state of the art," and it is safe to say that hand-operated presses will still continue to be an important factor in turning out the higher grades of work.

The steam presses are used almost exclusively at the Bureau for printing the backs of treasury and bank-notes, and for revenue and postage stamps. The first printing of any money is on the back. The printing of the face of the note (which is done on the hand presses) then follows. Then follows the numbering consecutively by automatic numbering machines. The final process is the imprint at the treasury of the seal of the Treasury Department, which makes the money valid. The signatures of the Treasurer and Register of the Treasury are printed in fac-simile, and not signed as many suppose. The national bank-notes, however, are signed in ink by the president and cashier of each bank.

The special paper used comes from the Treasury Department dry. It is then counted and prepared in the damping room for the presses. Women in the damping room receive so much paper each morning, count the sheets and give receipts for them. Layers of sheets are laid between layers of wet cloths, twenty sheets to a cloth, and then subjected to a strong pressure. When the sheets are turned over to the printer, his woman assistant counts them and certifies to the number, which certificate is witnessed by the printer, who thus in turn becomes responsible. Lock-boxes attached to each press register automatically every sheet printed. During the process of printing, before the plate is inked, it is warmed over a gas stove which is attached to the press. The plate is then inked thoroughly, so that the ink fills all of the engraved depressions. The surplus of ink is next rubbed off with a cloth, and it is finally rubbed off with the hand and polished with a whiting substance. The assistant lays on the sheet, and the final impression is made. This seems a slow process, and yet each hand printer and his assistant average from 800 to 1,000 impressions a day, each sheet containing four bills.

The functions of the steam power plate press are practically the same as those of the hand press, with



A NEW LECTURE EXPERIMENT.

the exception that the different operations are nearly all performed automatically by the press itself. The steam press consists of a large, square table, with four "planks" on which the engraved plates are carried. Sometimes only one plate is used at a time, and at others any number up to the capacity of the press, which is four plates. These plates are automatically and continuously carried around each side of the press by means of an endless chain, bringing them successively under the inking and printing rolls. One man and three women assistants are required to operate it. After the plate is inked by the machine, an automatic wiper removes the surplus ink, leaving but very little hand polishing to be done. One of the assistants then lays the sheet on the plate, which passes under the printing roll, after which the sheet is removed by another assistant, and the plate continues on to complete another cycle. The speed with which the plate is carried around the press varies with the work to be done, and can be regulated to suit. The number of impressions, however, average from eight to ten a minute. After printing the sheets are put in lock-boxes, and are taken by messengers in lots of 200 to the Examining Division, where they are counted and certified. If the count is correct, they are put in perforated racks and wheeled into the drying room where they are dried by artificial heat.

Just before the last stage of the work, and after printing, the sheets are placed between heavy sheets of cardboard, and subjected to hydraulic pressure. The pressure is 5,000 pounds to the square inch on money, checks and postage stamps, and 4,500 pounds on the revenue stamps. The next step is to take the sheets to the numbering room, where they are trimmed and numbered. Finally they are put in packages of 1,000 sheets and placed in the receiving vault of the Bureau, where they are kept until transferred to the Treasury Department. Each sheet has been counted more than fifty times, and it takes about one month to complete the printing.

A NEW LECTURE EXPERIMENT—THE BAROMETER.

By WILL C. BAKER.

IT is one thing to tell a class of beginners that the space above the mercury in the top of a barometer is a "vacuum," but it is quite another thing to make them realize that the pressure there is for most purposes negligibly small. This difficulty, which is felt by all teachers of elementary classes, arises from the fact that in the ordinary course of their experience the students are more or less familiar with gas-filled spaces that exert increased pressure when the volume is diminished, and *vice versa*; but in general their first acquaintance with a vacuum comes in the study of the barometer. In this connection the writer finds it well worth while to use the following demonstration.

A, *A*, in the accompanying sketch are two small, wide-mouthed bottles which, for convenience, are cemented into shallow recesses in the baseboard *B*. Through the tight rubber stoppers of these bottles pass the tubes *C*, *C*, and the legs of the inverted U tube *D* (as shown). At *E* is found a short stem with a well fitting tap. Mercury is poured into the bottles and is drawn up the tubes as far as possible by a water pump connected above *E*. The whole system is then carefully tilted forward until the liquid rises about one centimeter above the tap. Now after closing the tap and setting the apparatus upright again (the water pump being removed), one has two barometric columns to a common vacuum, and the mercury stands to the same height in each. The point lies in the complete mutual independence of these barometers. If the water pump be connected to either of the tubes *C*, *C*, the mercury may be drawn down to a height of only a couple of centimeters, without producing the slightest difference in the height of the other column. This behavior very vividly impresses the class with the idea that the only pressure determining the height of the barometer is the pressure at its base, and that therefore there can be no notable pressure on top of the column.—School Science and Mathematics.

NEW CHEMICAL DISCOVERIES.

CONSUL MAXWELL BLAKE, writing from Dunfermline, gives the following account of two new European compounds which are designed for a diversity of uses:

The discovery has just been announced in Scottish newspapers of a substance composed of a mixture of seaweed, carpet dust, goat's hair, Irish moss, and gums, together with some secret chemical ingredient or process, which produces a composition said to be a good substitute for leather and various other materials, as it can be used equally well in a fluid, pliable, or hard state.

It is admitted by the discoverer that his composition is not equal in quality to the best materials imitated; but he claims as to leather that it provides an excellent substitute for the manufacture of articles of the cheaper grades of goods. The product has already been made up into boots and shoes, and its durability successfully tested by policemen, postmen, and others whose duty involves a large amount of walking. Two or three thousand feet of belting in machine shops is also in use at the present time, to which purpose it is said to be especially well adapted, as it is impervious to oils and acids, is non-inflammable, and does not shrink under the varying conditions of the atmosphere.

In its hard state it is said to be a cheap and practical substitute for vulcanite, and can be purchased for less than one-fourth the price of the latter. Imitations of marble and wood are produced by hydraulic pressure, the seaweed suggesting the veins or grain. In its fluid state it can be applied to a floor, and when allowed to set it forms a permanent surface of linoleum. The seaweed is obtained from Devonshire, and the more expensive varieties for the manufacture of marbles from Japan.

Another chemical discovery, or rather rediscovery of what was an old Roman secret known to have been used about six hundred years ago, which likewise seems full of practical possibilities, is a liquid preparation to prevent iron rust and wall dampness. When applied to the bottom plates of ships it is said to prevent oxidation, animal or vegetable marine parasites and growths, and, besides preserving the life of the iron plates, will also add to the speed of liners and warships. When the inside of a ship is coated over with this liquid it stops the "weeping" of the inner skins of the iron sides, which, as shippers so well know, is so often the cause of much damage to ships' cargoes.

Freshly plastered rooms, when painted with the same preparation, admit of immediate occupancy or decoration, as the paper can be applied without delay or damage. The tests have extended over a period of many months and the results have been announced as successful. Inquiries to date, however, have failed to elicit any definite information as to its commercial manufacture, as it is reported that experimentation has not yet been concluded.

ROOM DISINFECTION.*

A NEW AND EFFICIENT METHOD.

BY W. B. McLAUGHLIN, M.D.

In order to make clear the advantages of the method of disinfection which I am going to describe, it is necessary to define the exact status of the art as applied to dwellings. The methods most prominently before the profession to-day are:

1. What is known as the "Maine method," i. e., obtaining formaldehyde gas by mixing 300 cubic centimeters of 40 per cent solution of formaldehyde and 150 grammes of potassium permanganate for each 1,000 cubic feet to be disinfected. The most prominent exponent of this method is the United States Public Health and Marine Hospital Service.

2. The "Walker method," which consists in dissolving 20 to 25 pounds of commercial aluminium sulphate in 5 gallons of water, adding to this mixture 5 gallons of 40 per cent solution of formaldehyde, and liberating formaldehyde gas by mixing 8 ounces of this mixture and one pound of unslaked lime for each 1,000 cubic feet to be disinfected. The most prominent exponent of this method is the New York health department.

3. The "Stewart method," which consists in thoroughly spraying the walls, furniture, and floor of the room with a 20 per cent solution of formaldehyde gas, and then spraying the mattresses, laying one on top of the other, and then the pillows, bedding, etc. The most prominent exponent of this method is the Philadelphia health department.

In the first two methods (the Maine and the Walker methods), penetration to any extent is not claimed, and it is the custom both of the Marine Hospital Service and of the New York health department to disinfect articles such as bedding, clothing, etc., in the steam autoclave. But in the Stewart method it is claimed that the disinfection is sufficiently perfect to render steam sterilization in the autoclave unnecessary. As authority for this procedure, I was referred to an article by Dr. A. H. Stewart in American Medicine, vol. x, No. 22. A careful perusal of this article, to my mind, failed to disclose evidence of penetration sufficient to warrant the abandonment of steam sterilization for those articles requiring deep penetration. The author says: "Our success with this machine in room disinfection led us at once to test the value of spraying bedclothing in the same way instead of hauling the clothing to the Municipal Hospital and running it through an autoclave. A series of tests was made in the every-day work of the disinfectors. The floor being sprayed, the mattress was then thoroughly sprayed and placed upon the floor, and the quilts, sheets, etc., were placed one on top of the other and sprayed. Our test objects, small, oblong tin boxes with lids, inclosing strips of cloth soaked in bouillon cultures of *B. coli communis*, *B. pyocyaneus*, and *B. subtilis*, were placed in the mass of clothing. When the lids of the boxes containing the infected test objects were opened, 500 tests showed 99.4 per cent killed. All test objects not killed were sporulating *B. subtilis*. These results induced us to stop the autoclave disinfection of bedclothing, except in cases of smallpox. This has been done, and as a result there has been a saving of nearly $400 per month."

According to this statement, the mattresses and each article of bedding were sprayed. If this were the case, it is evident that the killing of test objects placed as described would be of no value as evidence of penetration, no assurance being given that these test objects would have been killed had penetration been required through even one thickness of blanket. If each separate article of bedding were not sprayed no data are given by which the operator would know how often to sandwich in a sprayed article. In order to determine these points, I undertook a series of experiments, but when in the midst of them was considerably disappointed to find that this work had been covered by Dr. Rosenau, and published in a bulletin of the hygienic laboratory of the United States Marine Hospital and Public Health Service, entitled, "Formalin in Disinfection of Baggage without Apparatus."

As my work, so far as it went, is merely confirmative of Dr. Rosenau's, I will give his conclusions. Page 33 of the above-mentioned bulletin says: "Large quantities of formalin poured on absorbent material in the corners of, or suspended in a box, have practically no disinfecting power between layers of blankets or sheets, even after five days' exposure. The formalin neither evaporates nor liberates its formaldehyde in a closed container at ordinary temperature (18 to 25 deg. C.) in twenty-four hours. In two to five days the fluid will evaporate, but the formaldehyde is deposited as paraform on the spot where it was poured. This method of pouring the formalin on absorbent material is, therefore, totally inapplicable in the disinfection of baggage, in a closed container. Sprinkling formalin on baggage in a trunk or box may be depended upon to kill non-spore-bearing organisms, such as typhoid and diphtheria, through three layers of blankets. The method, however, is not a reliable one unless a sufficient quantity of formalin is sprinkled in small drops uniformly over the surface and between many layers. It cannot be depended upon to kill anthrax spores through one layer of blanket. Formaldehyde is given off from its aqueous solution in very small amounts at ordinary temperatures. The evaporation of the solution in a closed container is slow and uncertain. In using this method, therefore, great care must be exercised to sprinkle the formalin uniformly, and in small drops. It is best to keep the container in a warm place to facilitate the evolution of the gas. Use not less than 4 cubic centimeters of formalin, containing 40 per cent formaldehyde, over every square foot of surface between every third layer of blankets or their equivalent. Somewhat less will suffice for linen and cotton goods. This means the use of from 50 to 100 cubic centimeters per cubic foot. Increasing the amount from 2.5 cubic centimeters to 4 cubic centimeters per square foot does not correspondingly increase its power of penetration, but gives constant results. Increasing the time of exposure over twenty-four hours does not increase the penetrating power of the disinfectant. Pouring the liquid in one place, and splashing the liquid on with brushes will not suffice. The formalin must be carefully sprinkled in small drops and distributed uniformly over the surface, between many layers."

It is evident that in the Stewart method penetration can only be expected where the formaldehyde has been carefully sprinkled in layers and confined in piles of bedding, baggage, etc., and even under these conditions only to the equivalent of three layers of blankets.

One would expect that, when a body pervious to gas was immersed in a gas, in obedience to the law of diffusion the gas would diffuse through the body, always provided that the time element be sufficient. That formaldehyde does not do this we know, and the reason advanced is that the gas formaldehyde coming in contact with the fabric is converted into its solid polymeride trioxymethylene, and deposited on the surface of the fabric.

I have discovered that if the gas formaldehyde be mixed with vapor of carbolic acid, this tendency to polymerization does not seem to exist, and that the formaldehyde penetrates as one would expect, i. e., obeys the ordinary law of diffusion of gases.

The mixture which I have used is 75 per cent of a 40 per cent solution of formaldehyde and 25 per cent of carbolic acid. I use 8 ounces of this mixture to 1,000 cubic feet of air space, and allow the room to remain closed twelve hours. I have used a retort to volatilize the mixture, but, as a matter of convenience, usually saturated a sheet and hung it up in the room to be disinfected (an ordinary sheet will hold about 6 ounces of the mixture).

The test objects used were those of the New York Health Department, consisting of a small thread of silk infected with a resistant strain of *B. pyocyancus*. My exposures were always at night, from 7 P. M. until 7 A. M. I did not keep a detailed record of these tests, and, therefore, cannot give one, but I killed the bacteria on these test objects, when placed under the carpet; in the pocket of a winter coat and the coat tightly rolled and corded; through twelve layers of blankets; wrapped tightly in a handkerchief, and placed in a pasteboard box, the lid being placed tightly on the box; and in many other tests of this character. In no case did I get a growth in a test object exposed.

My results were so remarkable that I was inclined to question the accuracy of my own work. I asked Dr. F. M. Jeffries, director of the pathological laboratory of the New York Polyclinic, to make tests for me. He tells me that he has not as yet tested the penetrative powers of these mixed gases farther than through seven layers of ordinary hospital blankets, but in all of his tests up through seven layers of blankets the bacteria have been killed.

* Medical Record.

Means for the Destruction of Ants.—To destroy ants and their brood, liquid carbolic acid is an infallible medium. With this, the wall cracks and the runs of the ants generally may be smeared, or it can be poured into their breeding place. To keep and drive ants out of inhabited rooms, stand shallow vessels about, partly filled with petroleum.

THE SUDDEN DISAPPEARANCE OF PAIN.

WHEN a person suffering from severe pain has a sudden sense of relief it is generally assumed that his disease has taken an equally sudden turn for the better. As a matter of fact, however, such a symptom is generally the reverse of favorable, and may indicate impending disaster. This we learn from a lecture on "Some Clinical Aspects of Pain," by Sir William Bennett, delivered recently at the London School of Clinical Medicine and printed in The British Medical Journal. Sir William says:

Pain, speaking generally, is a secondary consequence, except in certain psychic conditions, in which it may be said, for clinical purposes, to be the primary factor. Hence pain indicates a primary cause, and spontaneous change in pain must mean an alteration in the condition of its cause. . . . Pain, except in purely physiological, that is psychic, cases is, in fact, associated with some other condition or symptoms which must also be concerned in its disappearance. . . . It is therefore obvious that any change in the character of the pain, especially its spontaneous disappearance, must, if it is a change toward normality, be associated with corresponding changes in the other factors of the association. In other words, in any given case, if the change in the nature or character of the pain be out of proportion to changes in the associated factors, the change is not always favorable, and should be regarded with suspicion. The predominance of pain as a cause of suffering is very apt to lead a patient, quite naturally, to think that the mere disappearance of it must be a symptom of approaching recovery. That this may not always be so is not, so far as my experience goes, sufficiently realized even now by some medical practitioners.

Setting aside cases in which the pain is relieved by the disengagement of a foreign body from a mucous channel or by the cessation of cramp as in colic, the spontaneous disappearance of acute pain may be set down either to relief of tension—for example, by the bursting of a cavity or the very rapid absorption of effused products, the occurrence of hemorrhage, etc.—or to the supervention of septic intoxication leading to indifference. The latter cause is the most interesting from a clinical standpoint, because of its great tendency to deceive, especially in young people, in whom the indifference resulting from septemia comes on more rapidly than in adults. It is therefore necessary, in the first instance, to have in mind two factors concerning the disappearance of acute pain: the actual relief of pain by a change in the lesion to which it is due, and a condition of mental torpor induced by septemia which leads to absolute indifference and contentment of a most deceptive kind, which if not realized may lead to very grave results.

Sir William describes some interesting cases marked by sudden relief from pain, in which, if its cause had not been recognized and the patient treated accordingly, life would have been lost. He closes with the following rules:

Sudden or rapid disappearance of pain should never be accepted without reserve on its own account as a sign of improvement. Sudden disappearance or rapid diminution of pain, unless it be coincident with proportionate improvement in the associated symptoms, is often a sign of impending disaster, and not an indication of recovery.

Gallstones are much in favor in Japan as a medicine, it being commonly believed that they possess efficacious properties when used in the treatment of diseases of children. They are classified on the market, to distinguish their origin, as oriental and occidental, the former being supposed to possess the greater virtue, and in consequence being of greater market value, though the latter also finds a ready sale at a slightly lower figure. The value of the article varies according to its quality, size, and color. The larger the size and the brighter the color the greater the market value. Broken or cracked stones are worth only half as much as perfect ones. The minimum price for good marketable stock and the lowest valuation at which the custom-house officials at Yokohama will pass the invoices is 40 yen, or $20 gold, per pound avoirdupois. From this figure the price runs up according to quality.

AN AUTOMATIC HEAT REGULATOR.

A DEVICE BASED ON A NEW PRINCIPLE.

BY OUR PARIS CORRESPONDENT.

A NEW form of thermo-regulator, or apparatus for obtaining a constant temperature, has been brought out at Paris by J. D. Fournier, who is connected with the physical laboratories of the University. The device is based upon a new principle, that of saturated vapor, and is claimed to be a great improvement in this class of apparatus. It consists of two essential parts, the first comprising one or more small metal

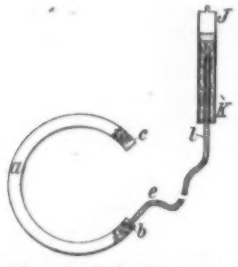


FIG. 1.—A DIAGRAMMATIC VIEW OF THE THERMO-REGULATOR.

tubes, which may be placed in the chamber or apartment which is to be heated. The metal tube is connected by a long capillary tube with the regulator proper, which serves to control the feed by turning on more or less steam into the radiator.

The mechanical part of the apparatus is composed of a light steel tube, *c a b* (Fig. 1), which is bent to form an open ring. This tube is filled with an inert and slightly expansible substance, such as sand, and the ends are stopped by two plugs, soldered to the tube. Affixed to the plug *b*, either by welding or by silver brazing, is the end of a flexible tube, *b e l*, whose length can be varied at will. The tube communicates with the interior of the ring, while the other end connects with a capacity of determined size, formed by a single tube, *J K*, or a set of such tubes placed together. The open end of the capillary tube projects in as far as the center of the tube *J K*. In the latter a liquid is introduced, which is as slightly volatile as possible, such as an oil or mercury. The liquid occupies more than one-half of the tube *J K*. Above this liquid a small quantity of volatile liquid is placed, and it is so chosen that within the temperatures at which the apparatus works, the liquid can be reduced to the state of a saturated vapor with a considerable tension. This done, the apparatus is hermetically sealed. The tube *J K* is the only part that is in reality sensitive to heat. Under the action of heat, the vapor tension of the volatile liquid in *J K* will vary, and this acting through the non-volatile liquid, will produce a corresponding expansion or contraction of the tubular ring *a b c*. If the end *b* of the steel tube be fixed, the movements corresponding to the variations of temperatures in *J K* will be transmitted to the free end *c*. In practice these movements are used for regulating the temperature.

In Fig. 2 we show how the apparatus may be applied to the steam pipe to automatically regulate the heat, by shutting off the steam more or less. The tubular ring is placed in a chamber, and the end *b* is attached to the cast-iron casing of this chamber. The

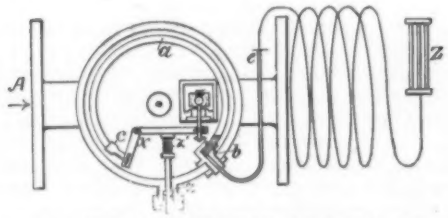


FIG. 2.—THE REGULATOR AS USED ON A STEAM PIPE.

chamber communicates with two pipes (*A* and *B*, Fig. 3), through which the main steam supply passes. A valve *o* serves to open or close the port connecting the regulating chamber with the pipe *A*. The valve stem *n* is connected by a ball and socket joint *q* with a diaphragm *t*, which is stretched across the chamber. A spring *w* presses down on the diaphragm, serving to hold the valve *o* normally open. The tension of this spring may be regulated by adjusting the cap screw *v*. The end *c* of the tubular ring is connected by a link to a lever *x* the opposite end of which is connected with a valve. This valve operates to open or close the port communicating between the chamber and the steam pipe *B*. A regulating screw on the exterior of the casing *i* may be operated to press a spring plunger *z* against the lever *x*, and thus adjust the latter to the desired temperature.

The apparatus works as follows: Steam from the pipe *A* enters the chamber by way of the open valve *o*, and is here under a pressure determined by the tension of the spring *w*; thence it flows through the valve into the pipe *B* to the radiators. As long as the heat in the apartment does not exceed the degree for which the apparatus has been set, the valve leading into pipe *B* will remain open, but as soon as this heat is reached it will close. As the closing of the valve produces an increased pressure in the chamber, the valve *o* also will close and cut off the steam from the regulating chamber. On the other hand, a slight drop of temperature in the apartment will cause the valve of pipe *B* to reopen, and as soon as the pressure in the chamber is relieved, the valve *o* also will open, permitting the steam to flow into the radiators.

In Fig. 2 the sensitive part of the apparatus is shown as consisting of a series of tubes, here designated by the letter *Z*. The capillary pipe *c* may be as long as desired, permitting the part *Z* to be placed at any suitable point in the apartment.

The apparatus depends for its operation upon the law of the variation of vapor tension with differences in temperature, and in this it differs from most others which depend upon the phenomenon of expansion. Suppose the regulator to consist of a cylinder *X Y* (Fig. 4) 10 square centimeters in cross section and 20 centimeters in length, and in which a piston *P* moves, whose stem acts upon the regulating mechanism. Place

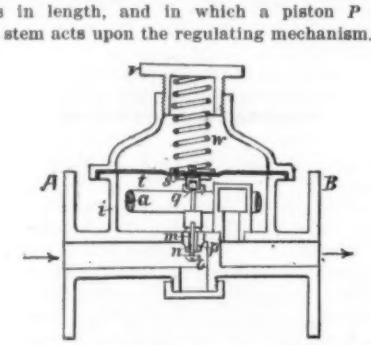


FIG. 3.—CROSS-SECTION OF MECHANICAL PART OF THE REGULATOR.

behind the piston an expansible substance, mercury for instance, whose coefficient of expansion is 1/5550. Let the mercury fill one-half of the chamber at a temperature *T*. When we increase this temperature one degree, the mercury will expand, and its increased volume will be about 1/55 cubic centimeter. Since the section of the cylinder is 10 square centimeters, this increase in volume will make the piston move only one-fifth of a millimeter. On the other hand, take the same apparatus and replace the mercury with a liquid *L*, which is capable of emitting at the temperature *T* a saturated vapor of proper tension, and suppose the piston to be in equilibrium at the same point in its course as before; if we raise the temperature of the system from *T* to *T* + 1 degrees, this increase will produce an increase in the tension of the vapor of the liquid, which will give rise to a constant force upon the piston capable of moving the latter indefinitely as long as there remains any liquid behind it, and if the piston offers no resistance, it will be pushed to the end of its stroke. Thus we see the great difference in sensitiveness which is obtained by the present method, and the advantage secured by the use of the saturated vapor.

Another and quite different use of the thermo regulator is in metallurgy. The utility of such an apparatus in most of the operations of metallurgy is unquestionable, from a standpoint of economy of fuel and from that of the quality of metal obtained. By using a proper form of apparatus, we can act upon the flues or piping of the furnace, according to the kind of fuel which is used. The main part of the apparatus for controlling the mechanism remains the same, while the part which lies in the furnace, namely, the sensitive part, is somewhat modified. As shown in Fig. 5, it is formed of two tubes *A* and *B*, preferably of porcelain or other refractory material. These tubes are of a calculated capacity, and are connected at their lower ends by a tube of smaller diameter. The upper part *E F* of the tube *B* is also of smaller diameter, and is inclined. The end of the tube *F* projects out of the wall of the furnace, and is connected with a reservoir *C* filled with mercury or other inert liquid. To fill the apparatus, the reservoir *C* is disconnected from the tube *F*, and a metal whose melting point is more or less high, according to the temperatures at which the apparatus is to be used, is poured into the tube *f* until the level *N* is reached. Then, when the reservoir is refitted to the tube *F*, a gas is introduced through the valve *R*, such as nitrogen, hydrogen, or even air

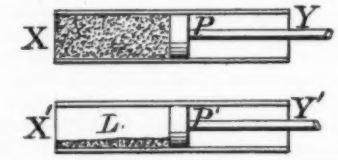


FIG. 4.—ILLUSTRATING THE DIFFERENCE BETWEEN AN EXPANSION AND A VAPOR TENSION SYSTEM.

under pressure, which fills the portion *N E F C*. Suppose we are to regulate temperatures of 1,200 or 1,300 deg. Centigrade, the metal contained in the branch *A* being silver. The apparatus is used as illustrated, with the left-hand part lying within the furnace. As silver melts at about 1,050 deg. Centigrade, it will vaporize above that point. The tension of the saturated silver vapor in the left-hand tube *A* will cause a lowering of the level of the melted silver, which will compress the gas contained in the part *N E F*. If we recall the law of tensions of saturated vapor, we will see that the action will take place as if the tension of the saturated silver vapor acted directly upon an incompressible liquid instead of on the gaseous column. The apparatus thus regulates with precision, and the pressure is transmitted from *C* by means of a long tube *f* to the mechanical part of the apparatus, which acts upon the valves or flues of the furnace.

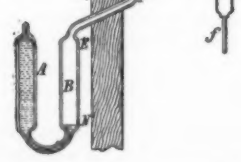


FIG. 5.—SHOWING THE THERMO-REGULATOR APPLIED TO A FURNACE.

HOW LONG IT TAKES A TREE TO GROW ONE INCH.

THE following appears in the Carriage Monthly:

To-day, by reason of the progress made in scientific tree cultivation, questions have arisen in the commercial and agricultural world that must be answered with sufficient accuracy to inspire faith in results in order to command investment of capital. For instance, the first query of capital is, "How long will it require to grow hickory, ash, white oak, or poplar trees to usable size?" Farmers and tree growers have no reliable unit rule to govern them, and there seems to be little published and nothing well authenticated in answer to this question, important as it is to commercial interests as well as to legislative authorities both State and national. . . .

Our method for reaching the subject comprehensively was to ask about forty of the country's prominent vehicle and wheel manufacturers, drawing their stock from territory where hickory, white oak, ash, and tulip are indigenous, to select and express to us short cross sections of these woods from the ends of rims, shafts, spoke billets, body material, bows, or what not; these to be selected for the average width of growth, and the size of each block to be about 1 inch lengthwise, 1 inch across growth, and ⅛ inch thick.

These blocks we examined carefully, and marked on each block a 1-inch space across the average size of growths of the annular rings. We then counted the number of rings within the inch space on each block and registered the total in ink thereon. The next thing was to count these totals on all the samples of each of the several kinds of timbers submitted, and in the usual

way thus ascertain the average number of years required for each kind of tree to grow one inch. In reaching this conclusion, we, of course, took only half the number of years recorded by the count, since the opposite side of any tree gives the same number of growths. An inch growth on one side represents two inches growth to the tree. . . .

This accomplished, we submitted the count, process, and result to scientific authority so well known to the world that the results will not be questioned. The blocks with recorded data will be in our office for the inspection and verification of any who care to personally inspect the same. In order to insure against the difference, if any, in locality where the blocks were obtained, our first intention was to report separately each of the States, viz., New York, Pennsylvania, Maryland, Ohio, Indiana, and Kentucky; but as the results from all the States were so nearly uniform, and because of the fact that many of the factories reporting buy timber in other States, we abandoned this plan. Instead we give the average west of the Alleghanies and east of the Alleghanies.

The results for the different woods are as follows. As will be seen, it may be said roughly that it takes a tree from four to five years to increase one inch in diameter:

Hickory—(West of Alleghanies) average number of years required to grow one inch, 4.87; (east of Alleghanies) average number of years required to grow one inch, 5.83.

Oak—(East of Alleghanies) average number of years required to grow one inch, 4.68.

Ash—(East of Alleghanies) average number of years required to grow one inch, 4.91.

Poplar—(East of Alleghanies) average number of years required to grow one inch, 4.

THE MINOTAUR.

A CURIOUS BEETLE THAT LIVES IN SANDY PASTURES.

BY HENRI COUPIN.

THE minotaur here described is not the monster of Greek myth, half man and half bull, but a humble living beetle which, in spite of its large size, is little known except to collectors of coleoptera. The name was suggested by the triple horn or fork which adorns the head of the male beetle and is very useful in his peculiar domestic labors. The minotaur chiefly frequents sandy sheep pastures where in autumn it digs a burrow which is easily recognized by the mound of earth at its mouth. This burrow is a simple vertical shaft of the size of a man's finger. At the bottom lurks a beetle, male or female, and the space above is filled with sheep's droppings. These constitute the food of the minotaur and their rounded form makes it easy for the beetle to roll them to his burrow.

This small burrow is only a temporary habitation. Toward December the minotaur excavates a shaft of larger diameter and about four feet deep and lines it with a thick coating of disintegrated sheep's dung which affords excellent protection against the cold. In this burrow the insect, still solitary, passes the winter in a semi-torpid state, but occasionally nibbles at its abundant store of food.

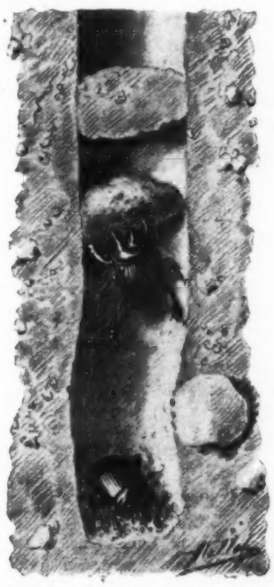
In the spring the beetles pair and go to housekeeping for the brief remainder of their existence. They begin by digging a large shaft four or five feet deep. The eggs, each inclosed in dung, are placed on the sandy bottom of the shaft under a great ball of crumbled and compacted dung which is destined to serve as food for the larvæ.

Unlike other burying beetles the minotaur collects sun-dried and hardened dung in preference to fresh droppings, but the tender larvæ cannot eat this food until it has been softened by long burial in moist earth, far below the surface.

In order to study the habits of the minotaur and to determine the division of labor between the sexes, Fabre inclosed pairs of beetles in glass tubes buried vertically in the ground and made oblique shafts through which he could observe the insects at work. In this manner he learned that in digging the shaft the female is always in the van or below. She alone ploughs the earth with her head and harrows and digs it with her serrated legs and feet. Meanwhile the male is toiling manfully to remove the loosened earth from the shaft. With his forelegs he collects a quantity of earth under him and molds it with his feet into a cylinder about an inch long. Then he crawls under the cylinder, impales it on his three-pronged pitchfork, steadies it with his front feet—or hands—and by means of his middle and hind feet, climbs up the vertical wall of the shaft with this heavy burden. After depositing it near the mouth of the burrow he cautiously climbs down the shaft and waits until his mate has loosened sufficient earth to make a second load worthy of his attention.

A month is occupied in these operations. When the burrow is completed the female remains at the bottom and the male turns forager. Having found a well dried dropping he rolls it to the mouth of the shaft, either by shoving it intermittently with his head or by walking backward and dragging it with his forepaws. Arrived at the mouth he enters and drags the ovoid mass of dung in after him, holding it with his feet and taking care to introduce it lengthwise. He gently lowers it, in this position, nearly to the bottom of the shaft and then turns it until its ends press against opposite sides of the shaft, the diameter of which is smaller than the length of the dropping. In this position the mass is supported by friction and it forms a floor, upon which other droppings can be accumulated without incommoding the housewife below. From these masses of hardened dung he then breaks off small fragments and drops them to the cellar beneath where the female subdivides them still further and presses them into a compact mass which, when completed, may contain the material of 300 droppings.

When this great work is finished the tired father



A PAIR OF MINOTAURS EXCAVATING THE FAMILY BURROW.

The female is at the bottom of the shaft; the horned male above.

abandons the burrow and crawls away to die. The mother, after laying her eggs, guards them until they hatch and remains with the larvæ until they are well grown—an example of maternal devotion which is exceedingly uncommon among beetles. In autumn she emerges from the burrow with her brood, which disperses to forage in the sheep pasture, and, having nothing more to do, dies.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

A Reuter message from Auckland states that a remarkable volcanic outburst began in the island of Savaii, in the Samoan group, on May 10. The flow of lava was the greatest in the history of the island. It amounted to between 2,000 and 3,000 tons a minute, and streamed down in a great river from 6 inches to 6 feet deep, stretching in an almost continuous sheet over a width of eight miles. On reaching the coast it flowed over the cliffs into the sea, causing steam to rise in great quantities. The lava destroyed many native houses, and for a time threatened the town of Matatua.

MALE MINOTAUR BEETLES HARVESTING SHEEP'S DROPPINGS.

WHAT THE ANCIENT GREEKS WERE REALLY LIKE.*

By PROF. JAMES RIGNALL WHEELER, Columbia University.

IT has been commonly recognized that in the work of the Greeks are to be found the beginnings of nearly every branch of intellectual activity in the western world, and that they in large measure marked out the categories in which this activity has shown itself. The world of scholars has certainly not failed to acknowledge its debt to Greece. But along with this ample acknowledgment, there grew up among persons less well-informed a popular conception of the ancient Greeks, and this conception, which has been singularly widespread, is very inconsistent with the view that they could have made any large contribution to the spiritual life of mankind. Prof. Gilbert Murray, in a recently published lecture, has described most concisely this popular and perverted view to be "a conception of Hellenism as representing some easy-going half animal form of life, untroubled by conscience or ideals, or duties, and the Greeks as a gay, unconscious, hedonistic race, possessing the somewhat superficial merits of extreme good looks and a mythically fine climate." "There is no reason," Prof. Murray continues, "to suppose the Greeks miraculously handsome, any more than to suppose that there is no dirty weather in the Ægean." It need not now concern us how this false idea arose or whether Prof. Murray is right, as he very likely is, in believing that it grew up through the attribution to the Greeks by ascetic Christian apologists of qualities which afforded an antithesis to their own views and which they erroneously made synonymous with "Paganism." It seems to be one of those perverted notions which often appear in history to obscure our vision of the truth. However that may be, this false view of the Greeks has existed, and one of the things which is putting an end to it, or which has already done so, is the more vivid conception of ancient Greece that archæology has brought. The setting of our former picture has become much more complete. When one is able to see the products of a civilization in large mass face to face, to become familiar not only with the works of its greater minds, but with those of its humble handicraftsmen as well, one may enter so fully and with such sympathy into the life of the people as to be pretty effectually protected against false

* Abstracted from a lecture on Archæology delivered at Columbia University in the series on Science, Philosophy and Art.

and one-sided judgments about them. To take but a single example: Within recent years a large number of sepulchral monuments have been uncovered which have been well published in an extensive *corpus*. It would indeed be a person of dull imagination who could go through the halls of the museum at Athens, where there is an extensive series of these monuments, or who could study the reproductions of the *corpus*, without having a lively sense of that kinship which we all feel in the presence of human sorrow.

There has been, too, another mistaken view of the Greeks, not this time ethical in purport, which has tended to make them seem exceptional in their development, and thus to stand rather apart from other men. This is the idea of a very sudden efflorescence of their art in all its perfection, not at all after the manner of most human things. Archæology, however, has shown that the growth of artistic skill, though no doubt rapid, was not abnormally so, and the view which reason should formerly have shown to be the true one is now not open to question.

THE AGE OF THE SUN AND THE EARTH.

SOME ANCIENT AND MODERN THEORIES.

BY PROF. FLORIAN CAJORI

BEFORE the time of the Scotch geologist, James Hutton, some 6,000 years was believed to indicate the age of the earth, and, indeed, of the entire universe. The advent of the uniformitarian school of geologists marks a radical departure from the old estimates. The pendulum swings from one extreme to the other. Boundless distances of time were now drawn upon. So great an antiquity of the earth seemed to reveal itself to geologists, as to defy all attempts at measurement. In the further pursuit of Hutton's line of investigation, Playfair and Lyell were unable to discover among the records of the earth and in planetary motion either a beginning or an end of the present order of things. They found no indication of infancy or decaying old age.

This convenient doctrine of infinite durability came to be rudely attacked by the physicists. Here, as in the history of the conservation of energy, the earliest investigator is Robert Mayer. To be sure, he did not attempt an estimate of the age of the solar system, but he discussed the preliminary question as to the source of solar heat. As soon as Mayer had convinced himself that energy can not be destroyed, and that the energy of the earth comes mainly from the sun, he began to study what Sir William Herschel had called "the great secret" of the maintenance of solar heat. In 1841, before the publication of his first paper, he asked questions relating to solar heat, in a letter to Baur, "Is it the glowing of the sun? Why does he not cool off? Is it a burning depending upon falling meteoric stones?"

In 1846 he had a paper ready on this subject. Being reminded by a friend that no one can be a prophet in his own country, he sent the paper to the Academy of Sciences in Paris. A committee of the academy was directed to report on this paper, but it failed to do so and the paper was ignored. It could be published only at his own expense. It appeared in 1848 under the title, "Celestial Dynamics." Mayer concludes that the sun can not be a glowing mass, sending out radiation without compensation; solar heat can not be due entirely to chemical changes; solar heat can not be due to solar rotation. He finally embraces the theory that solar heat is due to the energy of meteors falling into the sun. He did not overlook the fact that the resulting increase of mass of the sun would increase its attraction for the planets, and would shorten the sidereal year. He knew that observation does not disclose any variation in the length of the year. An easy explanation would be offered by Newton's corpuscular theory of light, according to which the sun sends out matter into space. But this theory was then known to be untenable. In this dilemma Mayer takes refuge in an idea which rests on a misconception of the undulatory theory of light, and he offers an explanation which is now easily recognized as invalid.

From Mayer we pass to William Thomson, the late Lord Kelvin, who, six years later, took up the very same problem and arrived independently at almost identically the same conclusions. That solar heat may be due to falling meteors was first suggested in England by Waterston. Unlike Mayer, Thomson sees no objection to the increase in the sun's mass resulting from meteoric showers, for, "according to the form of the gravitation theory" which he proposed, "the added matter is drawn from a space where it acts on the planets with very nearly the same forces as when incorporated in the sun." In an appendix to the paper, Thomson ventures an estimate of the age of the sun. This is the first attempt, made by a physicist, to compute the age of our great luminary and to prepare a mortuary estimate of it. He goes on the supposition that the solar energy of rotation is derived from the energy of falling meteors. He calculates that, allowing for the constant loss of solar energy by radiation, the sun could acquire its present energy of rotation in thirty-two thousand years. From an estimate of the limited amount of meteoric matter available near the sun, he concludes that "sunlight can not last as at present for three hundred thousand years." This calculation of the year 1854 attracted no attention at the time. Later, the theory was abandoned by its author.

Evidently the theory of solar heat was still in a very crude form. But important new ideas were brought into view in the same year, 1854, by Helmholtz, in a popular lecture at Königsberg, delivered on the occasion of the Kant commemoration. Unlike Mayer and Thomson, he starts out with the nebular hypothesis of Kant and Laplace, and derives solar heat from nebular contraction. During the contraction of the nebula from which sun and planets were formed, and also during the contraction of the sun, now assumed to be in progress, the kinetic energy obtained thereby is converted into heat and compensates for the loss of solar heat by radiation. He concludes that if the sun contracts the ten-thousandth part of its radius enough heat is generated to supply radiation for 2,100 years. His figures yield twenty-two million years as the probable age of the sun, on the assumption of uniform radiation and homogeneous density. Experimental data on the intensity of solar radiation, found later by Langley, reduced this age to eighteen million or less.

Helmholtz's theory was a tremendous advance on that of falling meteors, assumed by Mayer and Thomson. No doubt meteors fall into the sun, as assumed by Mayer and Thomson, but the Mayer-Thomson theory made demands upon these meteors that bordered on extravagance. We are certain that a part of the solar heat is due to falling meteors, but its amount is as nothing, compared with the heat resulting from the gravitational energy of shrinkage. Until recently these were the only important sources considered.

In the sixties fresh attacks were made on the problem of the age of the sun by William Thomson. In 1862 appeared in the Macmillan's Magazine an article, "On the Age of the Sun's Heat," in which he favors a meteoric theory like that of Helmholtz, by which there is no difficulty in accounting for 20,000,000 years' heat radiated by the sun. He concludes that we may accept "as a lowest estimate for the sun's initial heat, 10,000,000 times a year's supply at present rate, but 50,000,000 or 100,000,000 as possible, in consequence of the sun's greater density in his central parts." "As for the future, . . . inhabitants of the earth can not continue to enjoy the light and heat essential to their life for many million years longer, unless sources now unknown to us are prepared in the great store-house of creation." More detailed studies of the same subject were made in 1887, in a lecture "On the Sun's Heat," delivered before the Royal Institution of Great Britain.

In this lecture Sir William Thomson refers to a very able paper, "On the Theoretical Temperature of the Sun," by J. Homer Lane, of Washington, which establishes the apparently paradoxical statement that, within certain limitations, the more heat a gaseous body loses by radiation, the hotter it will become. This theorem was discussed in connection with the solar heat by Benjamin Peirce, Simon Newcomb and Sir Robert Ball. Results similar to Lane's were reached in the years 1878-83 in a series of very exhaustive papers by A. Ritter. A rival to the Helmholtz-Thomson theory of solar heat was advanced about 1882 by William Siemens, who imagined the rotating sun to hurl, by centrifugal action at his equator, enormous quantities of gas into space, which returned to him again at the poles.

A refinement of the theory as presented by Helmholtz was introduced in 1899 by T. J. J. See, wherein he abandoned the Helmholtzian hypothesis of a sun of homogeneous density and, using Lane's law, investigated minutely the more complex case of central condensation. Thereby the probable solar age was extended from about 18 million to about 32 million years.

Returning to the problem of the age of the earth, considered independently of the sun, we find William Thomson the great moving spirit. He approached the subject from more than one point of view. One argument for limitation of the earth's age was based on the consideration of underground heat. "The heat which we know by observation to be now conducted out of the earth yearly is so great that if this action had been going on with any apparent uniformity, the history of life on the earth could not exceed a few thousand million years." Another consideration leading to similar conclusions was based on the shape and rigidity of the earth. With Sir William Thomson, the age of the earth continued to be a question studied with great predilection. His aim was not so much to determine the exact age as to fix an upper age limit. As the years passed by, investigation supplied much of the knowledge which was at first wanting regarding the thermal properties of rocks, and Sir William Thomson was able consequently greatly to reduce this upper limit.

"The Physical Condition of the Earth" was the topic of Sir William Thomson's presidential address in 1876, before Section A of the British Association. He took the gradual increase of temperature downward to be on an average 1 deg. C. for 30 meters of descent and gave reasons for his belief that for great depths the rate of increase does not diminish. He concludes that if at great depths the temperature does not exceed 4,000 deg. C., then the geological age of the earth does not exceed 90 million years. This argument involves some very uncertain factors. Sir William Thomson has shown quite conclusively that the earth's interior is solid, but at what temperature the substance of the earth would begin to melt under the high internal pressures was a matter of pure conjecture.

About 1885 Carl Barus, of the United States Geological Survey, made a series of very important experimental researches on the physical properties of rocks at high temperatures, for the purpose of supplying trustworthy data for geological theory. Mr. Clarence King, in an article published in the American Journal of Science, used the data on specific heats, thermal conductivities and temperatures of fusion of rocks, which had been supplied by Barus, for a more accurate determination of the age of the earth. King concludes from these experimental data on diabase, "that we have no warrant for extending the earth's age beyond 24,000,000 years." A computation made by Lord Kelvin led to about the same figure. These results were embodied by him in his address of 1897 before the Victoria Institute.

What was the attitude of geologists toward these researches? In England, geologists did not pretend to be able to find any flaw in the argument of Lord Kelvin, but they were in a position described in the well-known couplet,

"A man convinced against his will
Is of the same opinion still."

To the geologist, yonder snow-capped peaks symbolized eternity; to the physicist, the mountains were as transient as the clouds.

A calm statement of the geologists' attitude was made before the British Association in 1892 by Sir Archibald Geikie. In one place he expresses himself as follows:

"Lord Kelvin is willing, I believe, to grant us some twenty millions of years, but Prof. Tait would have us content with less than ten millions. . . . I frankly confess that the demands of the early geologists for an unlimited series of ages were extravagant . . . and that the physicist did good service in reducing them. . . . That there must be some flaw in the physical argument I can, for my own part, hardly doubt, though I do not pretend to be able to say where it is to be found. Some assumption, it seems to me, has been made, or some consideration has been left out of sight, which will eventually be seen to vitiate the conclusions, and which when duly taken into account will allow time enough for any reasonable interpretation of the geological record."

Five years later an American geologist, Prof. T. C. Chamberlin, invaded the domain of physics and made a vigorous attack on Lord Kelvin's argument, challenging the correctness of some of his assumptions. This criticism did not secure the attention it deserved, for scientific events soon took a different turn.

Lord Kelvin's address of 1897 is permeated, as Prof.

Chamberlin puts it, "with an air of retrospective triumph and a tone of prophetic assurance." "It is only by sheer force of reason," says Kelvin, "that geologists have been compelled to think otherwise, and to see that there was a definite beginning and to look forward to a definite end of this world as an abode fitted for life." Nor was this feeling of retrospective triumph confined to Lord Kelvin or to the students of the problem of the age of the sun and earth. At the close of the century physicists and chemists gloried in the triumphs of their predecessors, in such achievements as are indicated by the words "conservation of energy," "conservation of mass," and "atomic theory." In physical research the nineteenth century was a golden age. It produced Faraday, Helmholtz, Mayer, Joule, Kelvin, Rayleigh, Rowland, and many other great men. With the close of the century timid souls doubtless feared that the golden age had come to a close, and they perhaps experienced strange emotions like those attributed to Adam in the Garden of Eden, on seeing the sun go down, not knowing that it would ever rise again.

Others were perhaps haunted by another fear—a feeling that the great and fundamental truths of science were all revealed to the full sight of man, and it now remained only to work out the less important details. Some doubtless felt disheartened because of lack of opportunity, as did the Edinburgh anatomist, Dr. John Barclay, a century ago. Dr. Barclay looked upon the great anatomists of earlier periods as "reapers who, entering upon untrodden ground, cut down great store of corn from all sides of them. . . . Then come the gleaners who gather up ears enough from the bare ridges to make a few loaves of bread. Last of all come the geese, who still continue to pick up a few grains scattered here and there among the stubble, and waddle home in the evening, poor things, cackling with joy because of their success." But the history of science shows that Dr. Barclay's reapers, gleaners, and geese do not belong to separate epochs. They are contemporaneous. The reaping, gleaning, and cackling go on as a rule in the same field, all at one time, in a grand comic medley of sounds. It is certain that anatomists had not so nearly exhausted their field one hundred years ago as Dr. Barclay believed that they had.

We are told that, about 1878, the president of a certain chemical society informed his hearers in an annual address that the age of discovery in chemistry was closed, and that henceforth we had better devote ourselves to a thorough classification of chemical phenomena. But at that very time Crookes was experimenting in England on high vacua, and the year following he electrified the British Association by his brilliant experiments on "radiant matter." Then came the Lenard rays and in 1895 the Roentgen rays, in 1896 the Becquerel rays and in 1899 radium, with its mysterious radiation. This was followed by the report that probably all matter is slightly radio-active. The study of these phenomena has shaken the old atomic theory, and calls for a re-examination of the principle of the conservation of energy and of matter. The earthquake in San Francisco did not shake buildings so violently as did these new facts shake the great edifice of physical science. The principle of the constancy of matter was called in question in an experiment of Kaufmann on particles shot off from radium. This experiment is hard to interpret, but I am not aware that J. J. Thomson, or Rutherford, or Soddy, or Boltwood, is denying the indestructibility of matter. One French experimentalist, however, Le Bon, has advanced the new theory of the destructibility of matter to explain the new phenomena. He advances his new theory as a demonstrated fact, and assumes to speak *ex cathedra*, when others observe extreme caution. Were he advancing the destructibility of matter merely as a working hypothesis, few could complain; but he puts it forward as a firmly rooted fact.

The principle of the conservation of energy has quite withstood all attacks. To be sure, Le Bon claims to have overthrown it, too, but the validity of his argument is questionable. Even scientists sometimes play with logic. You have heard the story of the Assyriologist who argued: "The Assyrians understood electric telegraphy, because we have found wire in Assyria." "Oh," replied the Egyptologist, "we have not found a scrap of wire in Egypt, so we know the Egyptians understood wireless telegraphy."

In the presidential address before the British Association in 1907, Prof. E. R. Lankester uttered the following weighty words: "The kind of conceptions to which these and like discoveries have led the modern physicist in regard to the character of that supposed unbreakable body—the chemical atom—the simple and unaffected friend of our youth—are truly astounding. But I would have you notice that they are not destructive of our previous conceptions, but rather elaborations and developments of the simpler views, introducing the notion of structure and mechanism, agitated and whirling with tremendous force, into what we formerly conceived of as homogeneous or simply built-up particles, the earlier conception being not so much a positive assertion of simplicity as a non-committal expectant formula awaiting the progress of knowledge and the revelations which are now in our hands."

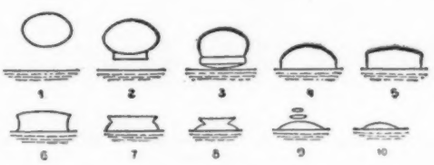
This same address touches questions of cosmical physics. It says:

"Radium has been proved to give out enough heat to melt rather more than its own weight of ice every hour; enough heat in one hour to raise its own weight of water from the freezing point to the boiling point. . . . . Even a small quantity of radium diffused through the earth will suffice to keep up its temperature against all loss by radiation! If the sun consists of a fraction of one per cent of radium, this will account for and make good the heat that is annually lost by it."

He continues to say:

"This is a tremendous fact, upsetting the calculations of physicists as to the duration in past and future of the sun's heat and the temperature of the earth's surface. The physicists, notably Prof. Tait and Lord Kelvin, . . . have assumed that its material is self-cooling. . . . It has now, within these last five years, become evident that the earth's material is not self-cooling, but on the contrary self-heating. And away go the restrictions imposed by physicists on geological time. They now are willing to give us not merely a thousand million years, but as many more as we may want."

Some of the views relating to radium, expressed in the summer of 1906 at the York meeting of the British Association, appeared to Lord Kelvin open to objection. It seemed to him that some of the younger men were carried away by the strangeness of the new phenomena and were ready to adopt the most extravagant theories when there was no logical necessity for abandoning old views and, in their intoxication, were embracing new hypotheses without exercising due circumspection. After the meeting Lord Kelvin boldly opened a controversy in the London Times. Almost single-handed the old warrior fought with great intellectual keenness against the transmutational and evolutionary doctrines, relating to the chemical elements, framed by the younger investigators to account for the properties of radium. Among his opponents were Sir Oliver Lodge, the Hon. Mr. Strutt, Mr. A. S. Eve and Mr. F. Soddy. It can not be said that Kelvin was victorious, but the controversy helped to define the points at issue. Among other things, Lord Kelvin said that there was no experimental foundation for the assertion that the heat of the sun was probably due to radium. He was still inclined to ascribe it to gravitation. Lord Kelvin also denied that it was proved that the heat of the earth is due to radium. It was possible, he claimed, that radium does not decompose under the conditions prevailing in the interior of the earth, and in that case it emits no heat.



REMARKABLE SUCCESSIVE APPEARANCES OF THE SETTING SUN.

In considering the perturbations produced by radium in the progress of our ideas, it is well to remember that, thus far, we have been able to experiment with radium in only small amounts. Prof. Lankester remarks that the Curies never had enough of radium chloride to venture on any attempt to prepare pure metallic radium.

"Altogether the Curies did not have more than some four or five grains of chloride of radium to experiment with, and the total amount prepared and now (1906) in the hands of scientific men in various parts of the world probably does not amount to more than 60 grains at most. When Prof. Curie lectured on radium four years ago at the Royal Institution in London he made use of a small tube an inch long and of one-eighth inch bore, containing nearly the whole of his precious store, wrenched by such determined labor and consummate skill from tons of black shapeless pitchblende. On his return to Paris he was one day demonstrating in his lecture room with this precious tube the properties of radium when it slipped from his hands, broke, and scattered far and wide the most precious and magical powder ever dreamed of by alchemist or artist of romance. Every scrap of dust was immediately and carefully collected, dissolved, and recrystallised, and the disaster averted with a loss of but a minute fraction of the invaluable product."

In a reinvestigation of the age of the earth it is extremely important to undertake extensive investigation of the amount of radium contained in the various rocks. Such researches have been begun by the Hon. R. J. Strutt. He has made determination of the amount of radium in rocks at the surface of the earth, and has found about 3×10^{-12} grains of radium as the average amount present in 1 cubic centimeter of soil.

From the rate of increase of temperature below the earth's surface and the heat conductibility of rocks, Mr. Strutt concludes that radium is confined to a comparatively thin crust of the earth. While these reasons are not conclusive, they are weighty. Our incomplete knowledge of the properties and the distribution of radium and other radio-active substances makes it necessary to suspend judgment on the age of the earth. There is no necessity that the question be settled immediately.

The same remark applies to the antiquity of the sun. Much depends upon the presence or absence of radium there. As yet this substance has not been found in the sun, but the presence of helium, combined with the fact that helium may be obtained from radium, renders the presence of radium in the sun quite probable. That radium affects the problem of the solar age was pointed out by Mr. G. H. Darwin in the following words:

"Knowing, as we now do, that an atom of matter is capable of containing an enormous store of energy in itself, I think we have no right to assume that the sun is incapable of liberating atomic energy to a degree at least comparable with that which it would do if made of radium. Accordingly, I see no reason for doubting the possibility of augmenting the estimate of solar heat as derived from the theory of gravitation by some such factor as ten or twenty."

In conclusion, it is very evident that, however unpleasant it may be for the older men to revise their theories to meet the demands of new observations, we have in radio-activity the entrance into a region of new knowledge which will cast light upon many a dingy avenue of philosophy. Great are the trials and great the final triumphs of experimental science.

In Norse mythology there is a wonderful tree called Igdrasil, whose branches spread over the whole earth and reach up into the clouds. At the foot of the tree, away down at the deepest root, is a well from which the tree draws its sap. To us of the twentieth century that tree symbolizes science. The well which nourishes the tree is the fountain of eternal truth.—Popular Science Monthly.

STRANGE FORMS OF THE SETTING SUN.

IN the course of a voyage from Stettin to Riga, Prof. Doss observed and sketched a number of very remarkable forms of the setting sun.

The phenomenon appears to admit of the following general explanation. The usual oblate form of the setting sun is due to atmospheric refraction which raises the lower limb of the sun more than it raises the upper limb, and consequently shortens the vertical diameter, because the lowermost strata of air are usually the densest and most highly refractive. Sometimes, however, the order of density is reversed at sea because the water cools less rapidly than the air and keeps the air stratum in contact with it warmer and less dense than higher strata. In these conditions the distortion of the lower part of the sun's disk is also reversed and the lower limb is drawn down to form a pear-shaped extension.

It may also happen that a sharply defined stratum of rarefied air floats at an appreciable elevation with denser air both above and below it. This was the case, apparently, on the evening of Prof. Doss's observations. So long as the sun remained above the rarefied stratum, partial images formed by total reflection at the upper surface of that stratum were appended to the lower limb of the sun as seen directly.

Partial images formed in the same manner at the lower surface of the rarefied stratum attached themselves to the upper limb when the sun had sunk beneath that stratum. The lateral indentations in some of the drawings mark the junction of the direct and reflected images. As the sun sank these indentations became deeper and finally the reflected images became entirely detached from the direct image and from each other. The straight vertical edges in some of the drawings are formed by the overlapping of a series of reflected images. These appearances are similar and analogous to those presented by the more or less continuous path of light that stretches over rippling water from the observer's eye toward a low-lying sun or moon.—Umschau.

The muscular tissue of chickens kept in a solidly frozen condition at 13 deg. F. shows marked histological changes even after one month in cold storage, according to Pennington and St. John. These changes are progressive and at the end of six months many muscle fibers are scarcely recognizable. The observations have been made on chickens of known history and which have been carefully kept, and upon chickens of the ordinary market type. The latter have been examined after storage periods of two and three years, as well as when stored for comparatively short lengths of time.

SCIENCE NOTES.

The annual production of sulphuric acid in Russia amounts at present, according to the Chimik i Pharmatzeft, to about 150,000 tons. The largest quantity is made at the Tentelieff factory, St. Petersburg, which produces about 24,000 tons. The importation of acid is now quite insignificant. The sulphur worked up amounts to about 20,000 tons, with 40,000 tons Russian and 70,000 tons foreign pyrites. In 1902 there were two factories working in Russia on the contact system, three building, and two of the largest then existing works preparing to adopt it. The Tentelieff factory is now about to do so, as is also the Rabenek factory at Moscow. The Nobel factory at Baku has begun to produce acid.

A universal instrument for recording horizontal movements has been designed with the object of eliminating as far as possible the deficiencies of present seismographs. The inverted pendulum type is chosen, and the "steady mass" made as large as possible, 2,000 pounds or more. To insure greater stability the whole of the pendulum is built underground in the mass of the pillar instead of on an erection above ground level as is more usual. The motion is transmitted to the recording gear by means of a modification of the spring bow and pulley apparatus, the smoked paper and style being preferred as the recording surface for moderate magnifications, while for high detail the photographic recorder is adopted.

For many experiments in laboratories of physics, physiology, and psychology, a place is needed from which all, or nearly all, external sound can be excluded. An absolutely noiseless room opens up numerous new possibilities of research. For this reason rooms have been constructed in many laboratories, but most attempts to produce a noiseless room have been more or less unsuccessful. A room at the Physiological Institute of the University of Utrecht, which has been constructed under the direction of, and used by, H. Zwaardemaker, is said to have proved quite a success. The room has no outside walls, and is 228 centimeters by 220 centimeters by 228 centimeters. The sides are of six layers as follows, beginning from the inside: (1) Trichopièse, about 5 centimeters thick. This is a felt-like material of horsehair, and covered with a net to keep the hair from falling. (2) Porous stone, 7.5 centimeters thick. This part of the wall is isolated from the floor by a layer of sheet lead, 3 millimeters thick. (3) A dead air space 2 or 3 centimeters thick. (4) Wood partition 2.5 centimeters thick. (5) A filling-in of ground cork and sand 4 centimeters thick. (6) A special composition of ground cork—Korkstein—6 centimeters thick. Total thickness of walls, about 11 inches. The ceiling is similar. The floor is least satisfactory because an old one had to be used. To prevent vibrations passing from board to board the joints were sawn through, and the crevices thus made filled with lead. The whole floor was then covered with lead 3 millimeters thick, and over this a very thick—1 centimeter—carpet, sometimes two carpets were spread.

W. Manchot and J. N. Friend investigated the absorption of carbon monoxide by cuprous chloride, bromide, and iodide, dissolved in different solvents. It was found that invariably compounds of one and the same type were formed, containing 1 molecule of carbon monoxide to 1 atom of copper. With cuprous chloride the same product, $CuCl,CO,2H_2O$, was formed whether the absorption of carbon monoxide took place in presence of water, hydrochloric acid, dilute ammonia, or dilute caustic soda solution. The compounds produced are dissociable, the degree depending on the temperature, carbon monoxide pressure, the concentration of the copper, and nature of the solvent. The absorption of the carbon monoxide in hydrochloric acid solution increases with the concentration of copper and the pressure of the gas, but decreases with increasing concentration of the acid, owing to the reversible reaction, $CuCl,CO,2H_2O + HCl = CuCl,HCl + 2H_2O + CO$. In presence of water it would have been expected that in all cases the absorption of carbon monoxide would be greater than in presence of hydrochloric acid, and that the concentration of the copper would be without influence. This is not the case, however, owing to hydrolysis of the cuprous chloride, the cuprous hydroxide formed not being capable of absorbing carbon monoxide. In presence of weak alkali or ammonia, hydrolysis proceeds further and the absorption of carbon monoxide decreases. In presence of strong ammonia, the absorption of carbon monoxide decreases strongly as the concentration of copper increases, and it is concluded that the absorption is effected by the ammonia compound of cuprous chloride, not by the chloride itself. From the fact that anhydrous cuprous chloride does not absorb carbon monoxide and from other considerations, the view is taken that cuprous chloride combines with carbon monoxide only in presence of water or such substances as aniline, ammonia, or the like, capable of acting in a similar manner, the first stage of the process being the addition of the water molecule or its equivalent.

ENGINEERING NOTES.

The rolling stock of the Japanese government railways system is not sufficient to meet the increased business of the different lines. The bureau has about 2,000 locomotives, an increase of over 40 per cent compared with last year, but this increased capacity is not keeping pace with the increase of traffic. Arrangements have been made to secure 200 locomotives belonging to the South Manchurian Railway, and 60 additional engines have been ordered abroad.

The report for 1907 of the General Omnibus Company of Berlin, the largest undertaking of its kind in Germany, shows that the company carried 133,800,000 passengers in 1907, as against 128,000,000 in 1906. Owing to the greater increase in expenses than in receipts, and after allowing for depreciation, there was a deficit of about $130,000 for the year. The directors' report states that the cost of maintaining and improving the motor omnibuses reached nearly 50 per cent of the original cost of purchase.

According to a United States Consular report, the number of miles of railways in Massachusetts increased during 1907 from 4,548½ to 4,618. The number of passengers carried was about 146,821,836, or an average of 75 persons per train mile, as against 137,834,000, or 73 persons per train mile, in 1906, thus marking an increase of 8,987,836 railway passengers in 1907. The amount of freight carried increased from 50,464,667 tons, or an average of 225 tons per train mile in 1906, to 53,806,796 tons, or an average of 233 tons per train mile in 1907.

The formal start toward building the railway to Hudson Bay was made on August 24, when two location parties left Winnipeg for the north in connection with the preliminary survey of the Hudson Bay railway. These parties comprised thirty men. They will travel over the Canadian Northern as far as Winnipegosis, where boats will be taken to the north side of the lakes. Both parties will work northward, one from the Pass and the other from a point about a hundred miles north of the present railway terminus. It is hoped to get further parties off by September 1, after which date the remaining parties will leave. The government will build the road and equip it. It is expected that all grain will be moved by this route within two years.

A study of the fuel values of coal burned while conducting some 540 boiler tests has shown that the value of the coal depends almost entirely on the number of heat units which it contains as determined by a calorimeter, these relative values being influenced somewhat by the amount and character of volatile matter and of ash present in the coal. This information has strengthened the position of the government engineers who desire to purchase coal on a specification which has for its basis of payment the British thermal units and ash in the coal. For the coming year a very large part of the coal purchased for the government will be paid for according to its value as determined in the government chemical laboratories. One of the largest purchases under this form of contract is for use on the Isthmus of Panama, and calls for the delivery of four hundred thousand tons within the year. Investigations of the washing and coking tests of coals have also shown the possibilities of utilizing poorer grades of coal than are commonly used, and point to a very considerable saving in our fuel supply. The experiments on the briquetting of coal have shown that the slack coal, which is otherwise difficult to utilize, may be made into artificial lumps and used with high efficiency in power plants or for locomotive use.

A piece of engineering work is being carried out in Italy at present which is of an extended scope, although it is but little known. This is the great irrigation canal of the Apulia region, which is to be used for the irrigation of several provinces. It is a masonry canal and has a number of branches leading in various directions. The total length of the great canal will be nearly 230 miles. However, there are many secondary canals or trenches of smaller size having different sections and leading from the principal canals, and the total length of these latter is no less than 800 miles. In order to carry on this extensive work in the best manner, the Italian government made an arrangement with the provinces interested in the irrigation project, these being the Foggia, Lecce, and Bari provinces. By this means, the capital which was raised for the purpose was $25,000,000, and it is estimated that the undertaking will cost nearly this amount to carry it out. The river Sele is to give the needed supply of water for the present system of canals, and the hydraulic work for taking off the water from the stream is constructed at a point known as Caposele. The principal canal leading from this point has a length of 150 miles, and upon this length there are over thirty miles of tunnels. The latter are given a diameter of 20 feet in general. A part of this tunnel traverses the mountain range of the Apennines, and this portion has a length of 10 miles.

TRADE NOTES AND FORMULÆ.

Ammonin washing fluid consists of soda and a substance insoluble in dilute acids, ground pumice stone or slag, the residue of any manufacturing process.

To Prevent Peeling of Iron Paint.—The iron or the iron articles must be washed, then warmed and then completely immersed in boiling linseed oil. The subsequently applied paint holds so firmly that neither frost, rain, nor wind can affect it.

Alabaster Cement.—Mix 1 part of powdered fluor-spar, 1 part of finest glass powder, 1 part of soda water-glass, to a thickish mass, apply this quickly and thinly to the broken surfaces and press them together. The cement, after a few days, is very hard.

Standard Metal.—An alloy of 60 parts copper, 38.2 parts of zinc, and 1.8 parts of iron, has the color of brass; when broken, the fracture resembles steel, is very hard and more resistant than iron, can be worked cold and hot, serves especially for axle-bearings.

Cresol soap is made by heating 60 parts of linseed oil in the water bath in a roomy, loosely stoppered glass flask and then, stirring the while, adding a solution of 12 parts of hydroxide of potash in 30 parts of water and 6 parts of alcohol. The mixture thus obtained is heated until complete saponification is assured, after which 100 parts of cresol, with a boiling point of 199 to 204 deg. is added. The fluid hereby obtained must be clear and of a yellowish brown color.

Glazed Coating on Copper-Plate Prints.—Steep gelatine for two hours in water, pour the water off and melt the gelatine in a tin vessel standing in hot water. A mirror glass plate, without blisters or scratches, perfectly clean, is polished with soapstone and coated with collodion. (Collodion: 25 parts ether, 50 parts alcohol, 1 part collodion cotton.) The print to be glazed should be pasted on strong white paper. After it is dry, dip it bodily in the heated gelatine and lay it with the picture side on the collodion-coated glass. Turn the glass over and remove all air bubbles by stroking and stick a second piece of paper on the print. The glass plate and print are set aside to dry and are dry in twelve hours. The dry picture can then be easily removed from the glass.

Belt Dressing.—I. A mixture of castor oil with 5 to 10 per cent of tallow. The belts are thereby kept pliable and preserved and their slipping on the belt pulleys is prevented. The tallow, the quantity of which to be added depends on the temperature of the place in which the belts are located, is said to prevent rapid contraction, where belts are seldom dressed. II. 2 parts of caoutchouc, cut in pieces, is heated to 140 deg. F. with 2 parts of rectified oil of turpentine. As soon as the turpentine is dissolved, add 1 part of ceresine and if desired also ½ part each of paraffine and ceresine, until it is all melted. In another, sufficiently large vessel, put 5 parts of whale oil and 2 parts of tallow, heat until all is dissolved, and then, stirring steadily, pour in the caoutchouc solution. When cooled, the mass will be solid.

Acetylene Black.—By means of the patented process of Berger and Wirth (Schönefeld near Leipzig) acetylene diluted with air is burned, the mixture being effected in properly constructed burners. From the intense illuminating flame there arises a light, slightly adhesive soot, which accumulates on the walls of the collecting chambers in very light flakes. Acetylene gives off three to four times as much soot or black as good oil gas. Acetylene black is a deep black, without any shading into brown and is of very good covering power. Rubbed down with varnish, it produces a useful printing ink that is notable for the extraordinary depth and purity of its color tone. Acetylene black, being free from tarry constituents, can also be used as a water color. Acetylene may be burned to good advantage in combination with other suitable gases. By enriching with acetylene, it is possible to use other gases, of less value, like oil gas, for the manufacture of black.

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